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EDITORIAL.

ITEMS AND NOVELTIES.

The Delaware Bridge, between Philadelphia and Camden, N. J.—[Read at the stated meeting of the Franklin Institute, December 21, 1870, by Hector Orr.]—The facts and inferences which I shall offer to the Institute are taken from the highly circumstantial and complete report of the architects of the work, prepared for the information of the Secretary of War, and which has been explicitly commended by the commissioners appointed to examine the same. Each pound of weight and each foot of surface have been carefully ascertained and set forth, leaving nothing farther on the subject to be desired.

From this long array of details we learn that, according to the design, the Bridge will consist of four spans over the water-way, suspended by steel wire cables, and of a raised roadway or approach at each end, at the respective sides of the river. The western ap-

proach begins at the eastern side of Second street, Philadelphia, at an elevation of 36½ feet above low water; ascending by a uniform grade of 5 feet per 100 feet, the roadway attains an elevation of 74·03 feet at the distance of 750 feet east of Second street, at the centre of the first pier. This pier is located immediately east of Delaware avenue. The approach rests partly on embankment with side walls, and partly on arches. Front street, Philadelphia, will be spanned by two arches over the sidewalks, and a central arch over the roadway at an elevation of 20 feet in the centre. At Water street the elevation of the grade admits of an arch over the entire street of 40 feet. Delaware avenue will be spanned by an archway of 50 feet chord.

From the centre of the first *pier* to the centre of the last *tower* the roadway describes an arc of a circle, the versed sine of which is 39 feet; the grades of the respective approaches being tangential to this curve. The Camden approach descends from a distance of 1350 feet, at the rate of 5 feet per hundred feet, terminating 250 feet east of Front street, Camden.

The river Bridge consists of two spans of 762 feet each—two spans of 738 feet each—and one double draw 120 feet in length between centres of piers at low water. The clear elevation above low water of certain points will be,—72 feet at Philadelphia front; 91 feet at centre of first span; 97 feet adjacent to the draw; 111 feet at centre of second span; 110 feet at centre of third span; and 91 feet at centre of fourth span.

The floor of the Bridge and its approaches will be 36 feet in width, divided into a roadway 20 feet in the clear between guards, and 24 feet between curbstones; and two sidewalks, each 6 feet clear of the trusses. Each line of travel is directed by double lines of iron tramways, so arranged as to accommodate vehicles of different gauges. The floor is constructed in such manner as to prevent undue oscillation. The material (except the planking) will be wrought iron. Transverse joists of rolled beams, 8 inches in depth, are placed at intervals of 5 feet, and extend the entire width of the floor. These joists pass between a central rib, composed of two wrought iron beams, respectively 12 inches in depth, forming a compound beam or truss 32 inches in depth, and extending through each of the spans. The floor is farther stiffened by two main wrought iron trusses, 10 feet in height, separating the roadway from the sidewalks, and by handrail trusses of wrought iron 4 feet high, pro-

tecting the sidewalks. Adjacent to the main trusses, and at each side, are built beams of wood 8 × 12, above and below the floor joists, with pieces 8 × 8 packed between the transverse joists. These timbers form continuous ribs, extending throughout the floor, and are not affected by the variations of temperature, and therefore afford an effective medium to resist the horizontal action of the stays. The iron trusses are provided with slip-joints, at intervals of 40 feet, to compensate for variations in length caused by changes of temperature. The floor joists will be securely trussed at centre, and fastened by suitable stirrups to the main trusses. The suspenders are attached directly to the floor joists immediately outside of the main trusses. The planking of roadway consists of one course of white pine, 2½ inches thick, laid lengthwise; one similar course laid diagonally; and one upper course of white oak, 2½ inches thick, laid transversely. The sidewalks will have one course of white pine planking and one course of white oak, 2½ inches thick. The lower planking will be bolted to the iron joists, the upper course being secured by wood screws. The lumber will be previously seasoned and treated by an improved preservative process, and be laid with coal tar between each course.

To provide against lateral movement the floor will have a system of effective horizontal bracing. The stays will be attached to the floor at intervals of 15 feet, within the tangent lines of the cables, and will greatly assist in sustaining the floor, reduce oscillation, and partially maintain the equilibrium of adjacent spans when under the effects of unequal loads.

The main cables (two in number) consist each of nineteen strands of steel wire-rope, each 2⅜ inches in diameter, and forming one combined cable, 11⅝ inches in diameter. To these cables are attached the suspenders of iron-wire rope, 1⅛ inches in diameter, at intervals of 5 feet. Near the centre of the spans the suspenders will be of solid round iron bolts, 1¾ inches diameter, to assist in preventing oscillation; and where the suspenders cross the stays they will be combined by wrappings of iron wire.

Saddles, movable on rollers, are provided on the top of each tower, to pass the cables and stays, and allow an equalizing movement between the cables of adjoining spans. When the cables approach the anchorages, they are attached to iron chains, composed of flat links; these will extend down into wells in the solid rock, and will be effectually secured by heavy cast iron anchor plates.

The piers and towers have received the special consideration of the architects and Bridge Company. The *first* pier at Delaware avenue has been designed with particular reference to the accommodation of the Ferry Landing. This pier will consist of masonry founded upon rock bottom. At the level of the avenue an archway 20 feet in width passes through the masonry, east and west. The stone work is carried to the floor level, from which rises the cast iron towers to sustain the cable. The *last* pier will consist of masonry founded on piles driven to the rock, and will terminate with cast iron towers above the roadway. At the draw piers rock is found at the depth of 88 feet below low water.

In place of piers of simple masonry sunk on caissons by the *plenum* process, massive iron cylinders have been designed for the foundation piers and towers. A sufficient number of iron pipes, of adequate section, securely bolted together, on an improved plan suggested by Mr. Speakman, will be driven to, and sunk into, solid rock. The interior will be excavated and filled with concrete. At low water, these cylinders will be capped and firmly braced; the mud will be removed from between and around them, the space enclosed by sheet piling and filled with concrete 10 feet in depth. The exterior, from high water to sufficient depth below low water, will have suitable timber protection to obviate all danger from contact with vessels; and iron ice-breakers of great strength are designed for each pier exposed to the current. At low water the tapering *piers* commence, which consist of iron columns, effectually flanged and bolted together. These are braced in the vertical and horizontal planes by suitable struts and strong wrought iron ties. The *towers* commence at the end of the roadway, and are constructed of tubular columns of cast iron, firmly braced in every direction, and capped by an immense bearing plate, which supports the saddles for the cables.

At centres of the towers the cables are placed 45 feet between centres, and are drawn together near the centres of each span, where they will be 22 feet from centre to centre.

The draw is located at the termination of the first span on the eastern side of the Philadelphia channel. At a distance of 150 feet from the draw piers, the floor lines will diverge, forming two branch bridges, which, with the direct bridge, will be continued to the draw piers. These will be connected with lifting draws, balanced by counter weights, and operated safely and rapidly by the most ap-

proved appliances, so that the draws may be raised or lowered in half a minute.

GENERAL SUMMARY.

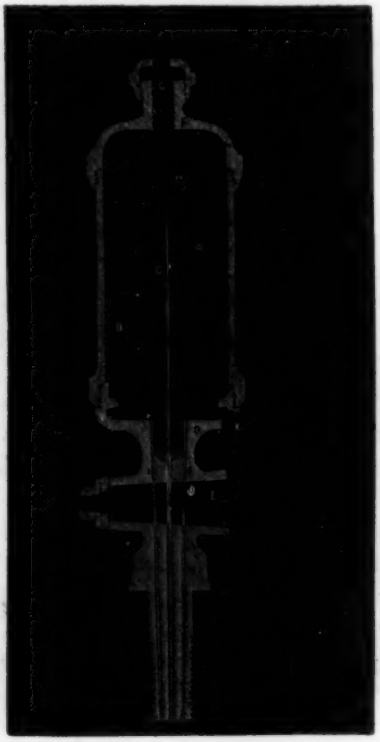
Length of western approach,	750 feet.
" of suspended Bridge,	3120 "
" of eastern approach,	1350 "
Total length of Bridge,	5220 feet.
Number of suspended spans,	4.
Length of first span, centre to centre of piers,	762 feet.
" of draws, " " "	120 "
" of second span, " " "	738 "
" of third span, " " "	738 "
" of fourth span, " " "	762 "
Height of first pier above low water,	72 "
" of centre of first span above low water,	91 "
" at end next to draw " "	97 "
" of centre of second span " "	111 "
" of " third span " "	110 "
" of " fourth span " "	91 "
" of draw, when raised, " "	171 "
Width of Bridge over all,	36 "
" of roadway clear of guards,	20 "
" of sidewalks in clear,	6 "
Deflection of cables,	75 "
Number of steel cables, main bridge,	2.
Diameter ditto (19 strands),	11⅞ in.
" ditto extra cables for draws,	4½ in.
Total capacity of cables and stays,	11,370 tons.
Ratio of maximum load to ultimate strength, as	1 to 5·2.
Ultimate strength of anchor chains,	12,000 tons.

We thus have the profile (pictorial and statistical) of a Bridge rather more than a mile in length, intended to connect Pennsylvania with New Jersey, and furnish a means of intercourse for travel and merchandise, independent of all vicissitudes of time and season,—and yet allow the passage up and down the Delaware river of all craft that have hitherto floated upon its waters. At the city of London, England, (whose commerce, certainly, has *some* weight in the social balance,) whenever her great hive swarms out over a few hundred yards of new territory along the Thames river, *a new bridge is built*, without regard to height of masts or rent of wharves and docks, and with no ruin, or even remonstrance, following the act. For her merchants and seamen know, that every mile by which they move their port towards the sea, shortens the voyage and lessens its risk; and if the city will thus insist on crowding

the ships, the "wooden walls" can stand the game quite as long as the brick ones can! In Philadelphia, however, we have a habit of trying to please everybody—and with no better success in general than attended the venerable attempt recorded in our early school books.

Nevertheless, one more attempt in the "conservative" line is here proposed in this Bridge, in which various tastes and interests are consulted; which will spare for the present the *square-rigged* tonnage of even Trenton and Tacony, and yet secure to the city of Philadelphia a proper footing upon her own Delaware.

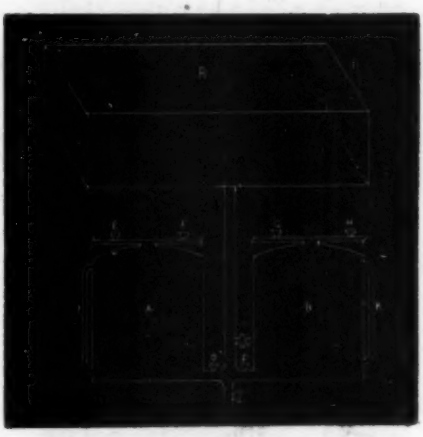
Lubricator.—*David Adamson's Patent, Dec. 7th*, 1869.—This apparatus consists of a piston, B, working in a cylinder, A, and upon an internal tubular rod, C. The cylinder and rod are secured concentrically to the base, D, which latter is connected with the parts to be lubricated by the usual screw joint, and is furnished with a plug, E, and three openings extending through and through, one in the centre, continuous with that in the rod, and the others, I, I, communicating with the base of the cylinder, A. All are opened or shut at the same time, by turning the plug, E. The cylinder cap, F, is provided with a central valve, the conical end of which enters the rod C at H. The piston and valve stem are furnished with the usual stuffing box packings. When the plug E is closed the cap F may be removed, the piston forced down, and the cylinder charged with grease: then by replacing the cap, setting the valve close into its seat, and the plug opened, steam enters the openings I, I, pressing against the bottom of the piston and forcing the grease, the amount of which passing from the cylinder A may be regulated by the valve G.



The piston is forced back usually by atmospheric pressure, the steam beneath it condensing when the plug is closed. The water of condensation runs back through I, when the lubricator is in use, vertically, or may be drawn off by cock at K.

A composite grease is used in this apparatus, the components of which we cannot here name; it is of the consistency of lard, and is therefore easily transferred to the cylinder, and is readily reduced to a liquid by the heat of the steam conducted through the mass of the piston and cylinder. J. H. C.

New Hydrostatic Gas Press.—Those who have experimented with the oxy-hydrogen light in connection with the stereopticon, gas-microscope and polariscope, have felt the necessity of a more durable, effective and convenient mode of applying the pressure upon the gases, than that ordinarily used. The new Hydrostatic Gas Press fulfils these requirements, and is designed as a substitute for other modes of producing the necessary pressure. It is an application of the well understood principle, that the pressure of water depends upon the height and not upon the quantity of water. The instrument to make this force available is represented in the figure, and an explanation of its modes of operation is here given. It consists of two cylinders, each with two orifices and an elevated water reservoir.



A and B represent the cylinders constructed either of copper or iron, and sufficiently strong to sustain, at a maximum, twenty pounds to the square inch. The lower orifices are for water, and are so arranged that it can flow in or out, as the operator may desire. The upper orifices are for the inlet and outlet of gas. H and E are connected with the jet, and F and G are used for filling the cylinders with gases. The cylinders are first filled with water by opening C, P, and O; the air escaping through F and G. When full, C, P, and O are closed. A is filled with oxygen by connecting F with the wash bottle of the oxygen generator; while the gas is entering, O

and D are open to permit the water to escape. The water gauge, made of glass, on the side of the cylinder, indicates the amount of of gas. O is closed when the cylinder is full.

The cylinder, B, is filled with illuminating gas or hydrogen in the same manner. The vessels being filled with gases, the stopcock D, in the outlet pipe, is closed, and the apparatus is ready for experiment.

The manipulation then consists in turning the stopcock C in the water inlet pipe, which should be done about half an hour before igniting the gases at the jet, to allow the gases to be condensed; as the water flows into the cylinders the gases are pressed upward, and forced through H and E to the jet. The reservoir R, when permanently arranged, should be supplied with a float stopcock and kept constantly filled with water. The pressure upon the gases will depend upon the elevation of the reservoir above the cylinders. A height of ten feet will give about five pounds to the square inch; twenty feet, ten pounds, &c. The amount of pressure upon gas bags rarely exceeds half a pound to the square inch, which can be obtained with the reservoir one foot higher than the cylinders. The reservoir may be dispensed with, and the water inlet pipe be connected with the city water pipes. This answers admirably, but is not so uniform as the reservoir. The portable form of this apparatus should be so constructed that the cylinders can be placed into the reservoirs.—J. G. M.

Telegraphic Possibilities.—A late number of the *Engineer* gives a refreshing collation of the possibilities of telegraphy on the completion of the Russian-American telegraph line.

A telegram from Alaska for New York, leaving Sitka, say at 6·40 on Monday morning, would be received at Necoleaf, Siberia, at six minutes past one on Tuesday morning; at St. Petersburg, Russia, at three minutes past six on Monday evening; at London, twenty-two minutes past four on Monday afternoon; and at New York, at forty-six minutes past six on Monday forenoon. Thus, allowing twenty minutes for each re-transmission, a message may start on the morning of one day, to be received and transmitted the next day, again received and transmitted on the afternoon of the day it starts, and finally reaches its destination on the forenoon of the first day—the whole taking place in one hour.

Directional Rain Gauge.—At the last meeting of the Philosophical Society of Glasgow, Mr. James R. Napier described a

new form of gauge, erected at Shandon, on the Gareloch, for discovering the wet winds, and the amount of rain they have produced. In meteorological observations these results are arrived at by means of expensive self-recording apparatus, not always reliable. Where private registers of rainfall are kept, the direction of the wind is not known with any certainty except at the times of observation. In the gauge described, the rain which falls during given winds is received into one or more of eight vessels surrounding it. If it rains while the wind is from the north, or between the N. W. and N. N. E., the north vessel receives it; if from the N. E., or between N. N. E. and E. N. E., the north-east vessel receives it, &c.; and the total amount of rainfall during all the wind's changes, is in one or more of the eight vessels, to be recorded when the observer pleases. The principle of the gauge is simply that of an ordinary rain gauge, very delicately balanced on a pivot, with a vane attached to be turned by the wind, and a spout of sufficient length to deliver the rain into surrounding vessels. To prevent the angular motions of the gauge from greatly exceeding those of the wind, a weight, balancing the vane, &c., is suspended as a pendulum close to, but not touching, a fixed ring surrounding it, as in Sir William Thomson's "governor." When the gauge turns suddenly or otherwise, the friction then produced between the weight and fixed ring by the centrifugal force due to the turning controls the angular motions. The measurement from the eight vessels may be by the usual graduated glass measure, but a tin measure, having a hundredth part of the area of the gauge, with a solid wooden piston or plunger, of nearly the same area, has been found to give by the sense of touch the amount of rain within three one-thousandths of an inch.

Itacolumite (Articulite).—The attention of scientists have recently been again directed to the structure of this singular, flexible rock, by an article in the *Chemical News*, from the pen of Prof. A. M. Edwards. The labor of Prof. E., of which the article in question is a summary, was undertaken mainly to examine and confirm the results obtained in 1867 by Prof. C. M. Wetherill, after a microscopic examination of the rock. The last named investigator determined the flexibility of the Itacolumite to be due to "small and innumerable ball and socket joints, which exist throughout the mass of the stone very uniformly," and proposed for it the name of "Articulite." Prof. Edwards' examination resulted unfavorably to this view of the subject, and it is in reply to his paper, above re-

ferred to, that Prof. Wetherill publishes another note on "Itacolumite," of which the following is an abstract:

In respect to the joints, it may be said that

(1). Each ball and socket does not admit of a great play, and is not smooth and perfect like that of the joint of a limb; it is, notwithstanding, perfect in principle of motion. The stone is built up of grains and congeries of grains loosely coherent, and forming irregular cavities in which are engaged projecting parts of other congeries or grains of sand, which are susceptible of a slight motion in the cavity—in some cases in one direction, and in others in several or in all directions. This freedom of motion is of the true quality of a ball-and-socket joint.

(2). The motion is *not* most "marked in a direction at right angles to the lamination." It is certainly so if a piece be taken of which the thickness is small in proportion to the other dimensions; but that is not the method by which the true motion is shown. A properly made section is susceptible of as much motion in the plane of lamination as at right angles to such a plane.

(3). The proof of the nature of the joints does not rest solely upon the microscope, although that alone is sufficient. The motions of the cylindrical rod afford an independent and equally convincing demonstration of the ball-and-socket character. There is no other kind of joint which could explain the motions of which this rod is susceptible, viz:—"It can be *compressed* and *elongated* in the direction of its axis, the extent of motion being a little over $\frac{1}{2}$ m. m. When one end is fixed, the other end may describe a circle of 34 m. m. diameter, and may be made to *touch every point in the area of the approximate spherical zone.* The rod can also *be twisted about its axis*, the torsion being 10°. I may add that, by shaking the rod near the ear, one may hear the clicking of the joints as the motion is arrested at the limit of their greatest play.

The nature of the curve (nearly a catenary) when the rod is supported by its ends, agrees with the joints which I have described, and confirms also the revelations of the microscope.

I have never seen anything so wonderful as this rod of itacolulite. When held by one end upward, it totters in all directions, so that no one, seeing it at a short distance, believes that it is a stone. A gentleman from California, to whom it was shown, suggested jocularly that it would do well to build houses with in his earthquake shaken State. Indeed, I have no doubt that a sufficietly high

and thin well built wall would be susceptible of a decided motion before cracking. The height of wall, so much greater than its thickness, would permit the play of the innumerable small joints, existing from the bottom to the top, to be perceived.

In order to see the joints, a thin section, supported at one end or at both ends, may be moved while under the microscope with a needle point; by changing the position of the section, a part may be reached at which the play of the joints may be perceived. They can also be seen by *dissecting* a flexible piece of the mineral, using either a fragment or a surface rubbed flat. The surface to be examined is inverted, tapped, and, as far as practicable, brushed free from loose grains. It is then examined under the microscope with a power of 40 to 60 diameters.

The attention of the observer is first attracted by the irregular pits or depressions formed by grains of sand. By very delicate touches with a fine curved needle point, the surface may be investigated; loose grains of sand are seen and removed. Touching other grains and congeries of them delicately with the needle, proves that some have motion in a cavity formed of grains of sand and cemented together. These are dissected out, and other movable groups are found. Some have less motion than others, and some are immovable. By patient investigation of the mineral in this way, the observer will rise satisfied that it is made up of joints of the character which I have described.

A New Pyrometer.—In a paper read before the French Academy, M. Lamy describes a pyrometer of peculiar construction, a condensed description of which will be found below. The instrument is a practical application of the phenomenon first noticed and described with numerous experiments by M. Saint-Claire Deville, and by him termed *Dissociation*. This phenomenon is simply that certain gaseous or volatile compounds, on being subjected to an increased temperature are partially and progressively decomposed to an extent dependent upon the temperature, and, moreover, that the tension of the elements of the mixture; or, as its discoverer termed it, the tension of dissociation increases, but is constant with any given temperature. M. Debray extended this fundamental law to sold substances, which consist of a fixed and a volatile constituent; as carbonate of lime.

In this particular instance, the tension of dissociation can be exactly measured. Heated in vacuo to 860° (C.), it decomposes itself

to an extent that the maximum tension of the disengaged carbonic acid equals 85 mm.; heated to 1040° the evolved gas acquires a pressure of 520 mm.

Just as water evolves a vapor, which for a certain temperature possesses a constant or maximum tension, so also the carbonate of lime, only at a relatively much higher temperature, evolves carbonic acid until, for this temperature, enough is disengaged to exercise a certain constant or maximum tension; and as with water the tension of its vapor increases with the temperature, so also does the tension of dissociation of the carbonate; and, finally, as a decrease in temperature, causes the partial condensation of the confined water vapor, so also does it bring about the partial absorption of the carbonic acid by the lime, so that soon the tension of dissociation, like that of aqueous vapor, will have fallen to a value which is constant for the altered temperature.

Upon this principle the simplicity and practical working of the lime pyrometer of M. Lamy will be readily comprehended.

It consists of a porcelain tube glazed without and within, which is closed at one end, and attached at the other to a two-armed glass tube containing mercury, or to any other manometrical system.

The porcelain tube is provided with powdered calcite or with pure marble, as far as it is exposed to the fire, and is then completely filled with carbonic acid by heating the marble to redness. When the tube returns again to its ordinary temperature the carbonic acid will have been completely re-absorbed by the lime, and the manometer will indicate a vacuum.

The chief advantages of this form of instrument are (by the author) stated to be its simplicity and the consequent cheapness of its construction, that it demands no calculation of its volume, and that it is not liable, at least during an operation, to get out of order. It can readily be attached to the majority of industrial furnaces, and the manometer can be attached at any desirable distance from the furnace. It is only necessary in practice to determine once for all the various maximum tensions of the gas corresponding to various temperatures.

Erbswurst (Pea Sausage.)—Dr. Dingler informs us in his excellent "Journal" that a cook of Berlin has discovered a process by which a preparation of peas may be kept without souring. The Prussian government has purchased the inventor's secret for £5,555. The Prussian war office has built an establishment at Berlin capa-

ble of producing 25,000 sausages of this preparation daily. It is composed of a mixture of bacon, peculiarly prepared pea flour, onions and other ingredients with salt.

The sausages are sent away in boxes, containing 500 or 600, weighing one pound each, for use in the army. They need only be boiled in water to be ready for the use of the soldiers. The daily ration of one pound is found to be sufficient for each man.

Solar Eclipse of December 22d, 1870.—It may be interesting to those of our readers who are not familiar with the fact, to know that two American parties, under the leadership of Prof. Pierce, Superintendent of the Coast Survey, have been organized to observe the phenomenon in Sicily and Spain. The expenses of the expedition have already been cared for by the liberal appropriation by Congress, of $29,000. Of the two parties into which the expedition is divided, the one to observe in Sicily will be under the direct leadership of Prof. Pierce, while the other will be in charge of Prof. Winlock, Director of the Harvard Observatory.

Journal of the Franklin Institute.—January, 1868.—The demands for sets of the *Journal* have recently been so great as to cause a serious diminution of the stock on hand. Especially does the management feel the want of the number heading this notice. In view of this fact, we are prepared to pay 50 cents for every unmutilated copy of that number which is sent to the Hall of the Institute; and we would respectfully request any of our subscribers who may have a knowledge of the existence and whereabouts of incomplete volumes to aid us in enlarging our stock of the wanting number.

CHEMICAL ITEMS.—Yttrocerite.—C. Rammelsberg.—Berzelius gave the name of yttrocerite to a mineral from the neighborhood of Fahlun (Finbo) which occurs along with gadolinite, topas, tantaliferous tin-stone and fluor-spar in a quartz vein in gneiss. It is massive, of blue or violet color, cleavable along the octahedral planes, harder than fluor-spar, and has a Sp. G. = 3·447.

From the analyses which Berzelius made in the year 1816 it appeared that yttrocerite consists of the calcic, yttric and ceric fluorides. Although the proportion of these elements in two analyses was nearly the same, yet Berzelius left it undecided, whether the whole was a combination or a mixture of fluor-spar with the fluorides of cerium and yttrium.

Some analysis which I have lately made of the yttrocerite from Finbo, make it an independent compound, I obtained

	I.	II.
Lime	47·27	49·32
Cerous oxide	9·35	16·14
Yttria	14·87	
Ignition	2·52	

Berzelius found 47·6—50·0 lime; 18·2—16·4 cerous oxide; and only 9·1—8·1 yttria.

When the atomic weights of cerium and yttrium are taken as 92 and 64, it follows from my first analysis that (Ce. Y) : Ca = 1 : 3, and Ce : Y = 1 : 2, and the whole is—

$$2 \left\{ \begin{matrix} Ce\ Fl_2 \\ 2\ Y\ Fl_2 \\ 9\ Ca\ Fl_2 \end{matrix} \right\} + 3\ aq.$$

Berzelius found Y : Ce = 2 : 3 atoms, and in this respect only do the analyses differ. This is either a consequence of the analytical method, or the proportion in which these two elements occur is variable.

A further examination has now shown that the cerous oxide contains almost one-half of lanthanic and didymic oxides. Moreover, that the material regarded as yttria consists of 30 per cent. of an earth precipitable by baric carbonate, and of 70 per cent. not precipitable. I have not penetrated more deeply into the nature of these little known bodies. Mosander found in yttrium three elements, yttrium, erbium and terbium. Bahr and Bunsen have endeavored to show that there are only the two first. Delafontaine declares the first opinion correct, but declares that the erbium of Bahr and Bunsen is identical with the terbium of Mosander. According to this chemist yttrium is not precipitated by baric carbonate, shows no absorption lines in the spectrum and has the smallest atomic weight, 58—60. The oxide is white and the basic nitrate also. On the contrary, erbium (Mosander, Delafontaine) is near 79, gives a yellow oxide, but no spectrum reaction. The terbium, finally, the atomic weight of which is highest, about 112, gives a red oxide, becoming green on ignition and a reddish basic nitrate. The substance regarded by Bahr and Bunsen as erbium shows peculiar spectral lines.* A. R. L.

* Ber. der deutsch. chem. Gesell. Vol. III., No. 16.

Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LX., page 381.)

The Sliding of Belts and its prevention.—"The *Praktische Maschinen Constructeur* affords us an excellent paper upon the above topic, the translation of which reads as follows:

"The most convenient and least expensive mode of transmitting power consists, undoubtedly, in the use of belts. Nevertheless, this system, owing to the sliding of the belts, is connected with a great loss of power that is seldom observed. Let us suppose two corresponding pulleys, of the same diameter, in motion at a moderate velocity. In case the tension of the belt is sufficiently great, and the pulleys not too small, it may be difficult at first to perceive the sliding of the belt; but if the rotations of both the pulley and the belt are counted, a difference in their number will, in nearly all cases, be discovered, the belt performing a less number of rotations than the pulley. We thus become aware that the belt slides upon the smooth surface of the pulley, owing to the fact that the power sought to be transmitted by the belt is greater than the friction of the leather upon the iron, and that this power overcomes the friction, more or less slowly, according to the circumcumstances of the case. In regard to this, it is self-evident that the velocity and diameter of the pulleys must be taken into account, for the friction is more easily surmounted at a rapid velocity than at a slow one, and pulleys of large diameter offer to the strap more surface, and this increases the friction. The consequent sliding of the straps takes place the more easily the greater the peripherical velocity, and the power to be transmitted, on the one hand, and the smaller the diameter, and the breadth of the driver or pulley on the other.

"The sliding of the belt, however, represents a loss of power and fuel. Supposing that the two corresponding pulleys, of equal diameter, the turning one makes 100 rotations in a minute, and the

turned one 95, there will be a loss of nearly five per cent. of the amount of force generated by the motor.

"It will become clear why the loss amounts to not quite five per cent. when it is taken into consideration that in sliding there will be a surplus of the transmitted force over the frictional resistance of the belt, which will be expended in the removal of the friction. This may be most easily recognized when we have a very considerable transmission of power, and when a perceptible sliding occurs, as, for instance, in driving a hydraulic press. If the pressure upon the piston of the pump is much greater than the friction of the belt upon the drum, the former is stopped in its motion, while the belt runs around the driving pulley, the motor itself thereby attains an accelerated velocity, from which it follows that the force required to overcome the friction is less than the one necessary for the working of the hydraulic press.

"In order to ascertain this loss of power for all cases, numerous and extensive experiments had to be undertaken. It may be stated here that this loss may amount to as much as twenty per cent., according to the circumstances. It may appear, at first, that the best means of guarding against this loss would be to construct the pulleys, in regard to diameter and width, so that the resistance of friction could not be overcome by the power transmitted. Nevertheless, upon a closer examination, it will become evident that this can, in most instances, only be accomplished at great expense. The outlay for leather belts is already considerable in an establishment of medium size, and would be still greater if all the belts were to be taken of such a width as is necessary for the prevention of sliding. Other means have, therefore, been proposed and applied. For instance, an endeavor was made to increase the friction of the leather upon the iron by spreading pulverized rosin or asphaltum upon the belt. In instances where the latter ceases to draw, the effect shows itself at once: but, nevertheless, only for a short time. On account of the pressure, the resinous powder penetrates the belt, so that its surface soon becomes as smooth as before, while the leather soon gets brittle and is gradually destroyed.

"The covering of the pulleys with wood is less objectionable, but it can find only a limited application. Only a wide pulley can be lined in this manner, but as the wood soon gets as smooth as the iron, it is necessary to roughen its surface repeatedly. This brings

about a change in the diameter of the pulley, as well as in the amount of force transmitted.

"A third preventive, which seems to have found extended application, consists in giving to the pulley a convex surface. But whether this prevents the belt from running off is yet to be proven. The writer has ascertained, that in consequence of the convexity of the drums, the belts will be stretched more in the centre than at the edges, and that as the frictional surface thus becomes smaller, the danger of sliding is increased.

"The covering of the pulleys with leather is undoubtedly the more advantageous, as thereby the frictional resistance is increased; the co-efficient of friction of which, with the leather, is considerably greater than that of the leather upon iron. The latter amounts to 0·25, the former to 1·25, which is just five times more.

"The resistance of friction may, nevertheless, be greatly increased by roughening the leather lining and keeping it thus by means of an alum or salt solution. The great benefit to be derived from this system has been demonstrated by practical tests.

"We give some of the results of the new system. A spinning-machine was made to produce, continually, a uniform thread, while by the sliding of the belt, it produced a thread containing knots and unequal spots. Ventilators which made only 1100 rotations per minute, in consequence of sliding, made 1400 after sliding was prevented. In a steam mill, with five run of mill-stones, each set ground 27 bushels per day after the pulleys were covered with leather, while before the amount ground per day was only from 23 to 24 bushels. Moreover, the troublesome falling off of belts, which previously occurred very often, ceased altogether. In a paper mill, a rag engine did fifteen per cent. more work per day after its pulleys were covered with leather. In sugar mills, for the beet crushers, the centrifugal and other apparatus, this system has been fully approved, and it cannot be doubted that it will be of advantage wherever introduced. It may be remembered that leather may also be used in establishments where the power is transmitted by wire-ropes. It is, in such cases, preferable to wood, cork, asphaltum and gum.

"The reason why the belts last longer is to be attributed to the fact that the increased friction allows a lesser degree of tension of the belts than would be the case if they were to run on a smooth iron surface. It is well known to every machinist, that for great

transmissions of power, the belts, if running on an iron surface, must be stretched to the utmost limit. This may be regarded as one of the causes of the rapid destruction of the leather.

"The same result is brought about sooner from the circumstance that, on account of the friction, fine particles of iron are detached, which, by combining with the tannic-acid and the fatty acids in the leather, form compounds, which, by penetrating the leather, cause the same to become brittle. By covering the pulleys with leather, this evil is prevented. But the chief cause of the rapid destruction of the leather is to be attributed to the sliding itself, which, as before mentioned, represents a useless loss of power. By the friction of the leather upon the iron, heat is generated, which causes what is called the 'burning' of the leather.

"Therefore, by running belts upon smooth iron pulleys, not only the power to be transmitted acts destructively upon the leather, but other causes also, which is not the case when leather-band wheels are employed. The application of leather to the wheel is very simple and easy, and may be done by means of glue by any intelligent workman."—*Technologist*, Nov., 1870.

From *Leonard's Mechanical Principia* we make the following extracts:

"If the power to be transmitted exceeds 20-horse, and circumstances will not allow the centre of the drums to be over 15 feet apart, the power should be transmitted by gearing."

A table is given which is based upon the following data:—One horse-power is transmitted by belts, 1·8, 1·2, 0·9, 0·72, 0·6, 0·514, 0·45, 0·4, 0·36 inches wide if carried over pulleys 2, 3, 4, 5, 6, 7, 8, 9, 10 feet diameter respectively, at the velocity given above.

"It is immaterial whether the smallest drum is the driving or the driven drum; if the diameter of the smallest drum remains constant, the width of the belt will remain constant; if the diameter of the other drum should be increased indefinitely."

From *Spon's Dictionary of Engineering*, p. 312, we take the following:

"Belts and drums form very effective friction-couplings. If a machine driven by a belt becomes accidentally overloaded, the belt slips upon the drum, and a break down is generally prevented. By the introduction of fast and loose pulleys the driven shaft can be set in motion or stopped with perfect safety, whilst the driving shaft is running at full speed. The motion of belts and drums is

much smoother than that of gearing, and they can be readily applied to machines which require a high velocity, where ordinary gearing would be quite inadmissable.

"The best description of leather for belts is English ox-hide tanned with oak-bark by the slow old-fashioned process, and dressed in such a way as to retain firmness and toughness, without harshness and rigidity. The prime part of the hide only, called the *butt*, should be used; these are cut out of hides in the preliminary preparing process, and tanned by themselves, afterwards stretched by machinery and allowed to dry while extended. Strap-butts of best leather can be permanently elongated 4 to 5 inches.

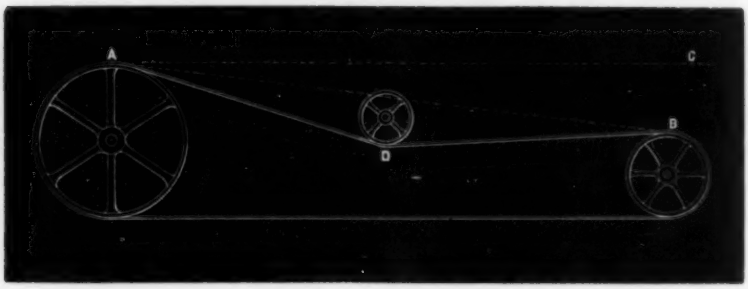
"For light work, belts of single substance are sufficient, the strips of leather being joined together by feather-edged splices, first cemented and then sewn. Single belting varies in thickness from $\frac{3}{16}$ to $\frac{1}{4}$ inch. For heavy work, double and sometimes treble layers of leather are required, cemented and sewn through their entire length. The material used for sewing is either strong, well-waxed hemp, or thin strips of hide prepared with alum. The latter is generally used in the North of England; but its advantages over good waxed hemp is doubtful. The thickness of double belting is from $\frac{5}{16}$ to $\frac{7}{16}$ inch.

"An improvement in the ordinary double belt has been introduced by Messrs. Hepburn & Sons, of Southwark, who have given much attention to this branch of leather manufacture. It consists in the use of a corrugated strip of prepared untanned hide for the outer layer of the belt, and the usual tanned leather for the inner layer, rivetted together by machinery. The rivets are made of copper or malleable iron, and have their ends spread, bent and driven in flush with the surfaces of the layers. Metallic sewing of this kind is also applied to double belting made entirely of leather, and has been found to work well, and is more durable than ordinary hand-sewing.

"The drum should be $\frac{3}{16}$-inch per foot of width, rounding except in the case of small high-speed pulleys, which should be $\frac{3}{8}$ to $\frac{1}{2}$-inch.

"In order that the natural tension of the belts shall remain constant, and not exceed, though equalling the value calculated, it is requisite to use *tension rollers*. The weight, w, of these rollers is found by the approximate expression, $w = \frac{2\ T \cos.\ a}{\cos.\ b}$; wherein a is

half the obtuse angle A D B, formed by the belt upon which the weight rests, and may be assumed *a priori*; b the angle between the line A B and the horizontal line A C: that is, the angle B A C = b, and T = tension on tight side.



"In fixing the belt, care must be taken to give it such a length that, when at repose, it shall only have a minimum flexure."

(To be continued.)

THE ALLEN ENGINE.

By Charles T. Porter.

(Concluded from Vol. LX., page 387.)

Lubrication.—Careful attention has been given to this subject. The valves and cylinder are fed by the displacement lubricator shown in the plates, and which is fixed on the steam-chest. To fill it, the plug at the top is unscrewed, the steam having been shut off from it, if the engine is running, and the water is drawn off with a siphon tube. The lubricator is then filled to the top of the central tube with melted suet, and the plug is replaced and steam turned on. The steam continually condenses in the space above the liquid surface, and the water formed sinks through the suet, causing the latter to overflow and pass down the tube. At the end of ten or twelve hours it will be found to be, perhaps, half gone, and should be filled as above. This lubricator admits of no other attention, and, as everywhere in this engine, the continuous and uniform action insures excellent lubrication, with the greatest economy.

The guides are oiled automatically by the arrangement shown in Plate I. The wicks can not be pushed down far enough to be

caught by the cross-head. The oil is taken from the upper guides, passes by four passages through the body of the cross-head, and is distributed over its lower surface. These need no attention, except to see that the wicks are in working order.

The crank-pin is fed by a novel device, perfect in its action, and which completely removes the most serious difficulty that has been encountered in running engines at a proper speed. This arrangement, and the course of the oil, are shown in Figure 1, Plate I. The lubricator is fixed on the pillow-block, and the oil is taken from it on a plate called a radiating-plate, which is attached to the crank, and the crowning surface of which, touches the end of the wick at each revolution. The oil on this plate takes the radial motion, and is led directly to the surface of the crank-pin.

The engineer can, while the engine is running, observe the action of this lubricator, refill it, adjust the wick, or supply additional oil to the pin by dropping it on the tube. If the passage becomes obstructed from using bad oil, a little weak lye will clear it, changing gum into soap.

The eccentric is oiled in a similar manner. The cross-head pin is fed by a wick from a cup set over the guides. A bridge in the enlarged end of a tube is so placed on the connecting-rod that it rises to touch the wick at the beginning of each forward stroke.

This system of lubrication enables these engines to be run continuously for any length of time, and with only the attention necessary to refill the lubricators and oil the valve gear; while the action of the lubricators is not liable to derangement from the motion of the engine, however rapid this may be.

Economic value of a higher piston-speed.—The chief claim of this engine to the position of excellence rests upon its superior economy of steam. While exhibiting, perfectly, every economic feature which is found in the best slow-running engines, it possesses an additional important element of economy in its speed. The advantage, in this respect, which higher speed confers is easily explained.

The loss in the steam engine, which expansive working cannot diminish, but, on the contrary, tends to increase, is that which arises from condensation of the steam while being used. Steam is only the medium for the conversion of heat into mechanical work; but, before this conversion can be effected, a large proportion of its heat is liable to be lost. This loss is not, except in a trifling degree, from external radiation; it is internal, and arises from the enor-

mous facility with which water, and especially the vapor of water, abstracts heat from, or imparts it to, bodies in contact with it, which are warmer or colder than itself.

Steam, on account of the perfect mobility of its particles, and the velocity with which these impinge against the surfaces exposed to them in an engine, keeps the temperature of these *surfaces* very nearly identical with its own, however suddenly or extremely this may be varied.

The action, during one revolution of an engine, is this: At the commencement of the stroke, and up to the point of cut-off, more or less water is present in the cylinder. Let it be supposed that, at the point of cut-off, the temperature of the steam, of the water present, and of the surfaces of the cylinder, piston, and cover is 320°, which is the temperature of steam, and the boiling point of water, under a pressure of 75 pounds on the square inch, above the atmosphere; and that the cut-off takes place at such a point in the stroke that the pressure will, by expansion, fall from the above pressure to that of the atmosphere, at the end of the stroke. Simultaneously, the temperature and the boiling point fall 108 degrees, or to 212°, and will remain at this point through the return stroke.

During the expansion and the return stroke all the water present is evaporated, and passes with the exhaust into the atmosphere, as steam, provided the large amount of heat necessary to effect this change of state can be abstracted from the metal. Then, at the commencement of the next stroke, an equal portion of the entering steam is condensed to restore this heat, which the very water formed by such condensation will, when relieved from pressure, immediately rob from the metal again, by reëvaporation, and carry into the atmosphere; and so at every stroke the ceaseless waste goes on.

The water which, to impart heat to the cylinder, piston and cover, was condensed from the entering steam, as a dew upon their surfaces, in reëvaporating during the expansion and the return stroke, instantly cools these *surfaces* nearly to its own reduced temperature. But the mere surfaces can supply no appreciable amount of heat. It must be brought from the interior of the metal by conduction, and this requires time. Therefore such evaporation is a gradual operation, and not an explosion, and the condensation of the entering steam is partial, and not total.

Time is the necessary condition without which this wasteful action cannot take place, and the extent to which it proceeds, is, other

things being equal, directly as the time allowed. Mr. Isherwood was able, by running the engines of the steamer Michigan very slowly, to more than neutralize, in this manner, the gain from a high grade of expansion, and to show instead, a serious loss.

If the piston of an air-gun is slowly pressed down, only a slight increase of temperature is shown in the chamber; but if this is done smartly, heat is developed which will ignite tinder. Now, the same work is converted into heat in each case, only in the last one very little time is allowed for the metal of the chamber to conduct it away. So in this engine the sudden compression at the end of the stroke develops heat; the rapid action allows but little time for this heat to be diffused through the metal, and it is mostly or wholly available to prevent the condensation of the entering steam. The more the subject is examined, the more obvious it will appear that, as only time is necessary for *all* the heat contained in the steam to be lost; so, on the other hand, rapid speed of piston is an important means of its economy.

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col O. W. Childs, C. E.

(Continued from Vol. LX., page 395.)

The average annual fall of rain and snow, in the State of New York, during the period of ten years preceding that of 1846, as appears from the annual Report of the Regents of the University for that year, is 34·14 inches, and the greatest fall in any year, during the same period, was 37·04 inches, and the least 32·10 inches.

Although the aggregate fall of rain in the month of May, 1850, as appears from the above statement, was 9·14 inches, there was no sensible rise in the river or lake until the 5th of June. The quantity of water that passed from the lake when at its greatest depression on the 4th of June last, as ascertained from a careful guage of the river at its minimum flow, was 11,930 cubic feet per second. The flow in the San Juan, immediately above the junction of the San Carlos river, as guaged on the 15th of July, was 19,300, in the San Carlos at the same time 16,547, making the whole quantity flowing in the San Juan, below the San Carlos, 35,747 cubic feet per second. On the 8th of August, the quantity passing in the San Juan, above the Serapiqui, was 39,526, and in the Serapiqui 13,266, giving to the San Juan, below the Serapiqui, 52,792 cubic feet per second. The flow in the San Juan, immediately above the Colorado, as guaged on the 20th of August, was 54,380 cubic feet

per second, of which 42,056 passed through the Colorado branch to the ocean. and 12,324 through the San Juan. Subsequently to the 5th of June, the river was more affected by rains, and on the 19th September, at the taking of the last observations previous to leaving the country, the lake was found 2·55 feet above its lowest stage, or the level it occupied the preceding May; it probably continued to rise until the following November, the usual termination of the wet season. Owing to the subsequent rise in the river, the above quantities were correspondingly increased to those given in a preceding table.

The lake fell from its greatest elevation on the 23d December, 1850, to its lowest, on the 27th of April, a period of 125 days, 3·43 feet, and continued about at this latter stage to the 5th of June.

The quantity discharged from the lake, when elevated 343 feet above its lowest stage, as estimated from the guages, is 18,059 cubic feet per second, and allowing the discharge gradually to diminish to 11·930 at the end of the above 125 days, would give a mean flow for this period of 14,995 cubic feet per second, or 899,700 cubic feet per minute, from which deduct the amount before shown to be required for the canal, 105,130, and it gives 794,570 cubic feet per minute, or for the whole period of 125 days, 143,022,600,000 cubic feet as the quantity that passed from the lake, in excess of that required during the same time for the canal. If the average of the area of the lake be taken at 110 miles in length by 25 in breadth, which probably would not vary essentially from the truth, this quantity in passing from the lake reduced its surface 1·87 feet, which, deducted from 3·43 feet, the whole fall, leaves 1·56 feet as the amount of its reduction by evaporation, in which is also included the whole supply of drainage from the surrounding country during the same period; thus showing, that it will be necessary to commence at the close of the wet season, with an excess of surface elevation of the lake, of 1·56 feet above that which it must necessarily have at the close of the dry season, an amount that may very readily be held in reserve, and the flow regulated by means of gates on the crest and in the body of the dam.

It is not known that this would to any very great extent prove injurious at any locality: between the Castillo and Toro Rapids, some lands would be flowed that would otherwise be susceptible of cultivation; the immediate valley being narrow, the amount that would be thus occupied by water is quite small.

Between the Toro Rapids and the lake, the low flats lying between the river and upland, occupy a large portion of the distance, and alternately varying from a few rods on one, to say half a mile on the opposite side in average width, and having an elevation varying from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet above the surface of low river, they are entirely submerged during most of the wet season, and are principally covered with an aquatic plant, of a light spongy texture, known as the Coroza, a species of wild palm, growing some 30 or

40 feet in height. These wet lands have now no value, and were they permanently flowed to the depth contemplated, the facilities for communication between the river and upland by boats in the channels of the lateral streams, would be improved, and the atmosphere rendered more healthy. The banks bordering the sides of the lake, so far as observed, are sufficiently high, and whatever may be their elevation at other places, it is not perceived that injury could result from continuing the surface of the lake at the elevation it now occupies so large a portion of the year. It is certain that no improvements would be disturbed, and the means of access at numerous points on the lake for purposes of commerce, would probably not be impaired.

No land worthy of note would be flowed by dams from Nos. 2 to 7 inclusive; the country along the river is hilly and the banks are generally elevated above that of the level, to which it is proposed to raise the water by these dams.

In the preceding table before given, of inclination of surface, &c., the inclination of that portion of the river above the Toro Rapids is stated at 0·12 of a foot per mile; this multiplied into the length in miles of that portion of the river, gives 3·26 feet as the inclination of its surface in time of maximum flow, an amount that would be too great to admit of a convenient control of the flow from the lake, by means of the Castillo dam. It should be stated, that in the calculation of all the inclinations and velocities given in the table, no allowance is made for enlargement of volume by a flow beyond the immediate channel of the river. In the case under consideration, this enlargement will be quite sufficient to bring the inclination within such limits as will render the flow from the lake perfectly controllable by the method before stated, and usually adopted in such cases.

Capacity of the Canal.—From information obtained from the most popular builders and others skilled in the science of the model and tonnage of steamers and other vessels, the opinion is ascertained, that steamers of from 1,800 to 2,400 tons, and merchant sailing vessels of a somewhat greater burthen, may be so constructed as to be well adapted to the passage of the locks, for movement in the projected canal and for sea service. The former in navigating the canal would be propelled by their own power, and the latter would necessarily be tracked by steamers, especially constructed for that purpose, excepting that portion west of the lake, and on that inland, between Dam No. 7 and the harbor of San Juan del Norte, where, owing to the additional delays that would be caused by a propelling steamer in passing the locks, animal power might probably be used with more advantage. The canal would also probably be navigated by brigs, and other coasting vessels of a smaller class, which, if admitted, would of course reduce the movement of the maximum tonnage, of which the canal would otherwise be capable.

The average time required for steamers and other vessels to pass

a lock is estimated at 24 minutes, or 60 per day—the steamers requiring something less, and the larger class of sail vessels a little more than that above stated.

The average rates of speed with which the steamers may safely move in the inland portions, without injury to the vessel or the banks of the canal, is estimated at two and a half miles per hour, on the river portions seven miles per hour, and on the lake the same speed may be attained as on the ocean, say eleven miles per hour. Sailing vessels propelled by horse power might move on the canal at the rate of two miles per hour, and by steam-tugs in the river and lake with an average speed, of say four miles per hour.

The time, then, occupied in making a passage from ocean to ocean, in hours, would be for the steamers

47·09 miles of canal navigation, at the rate of 2½ miles per hour	18·83
90·80 miles of river navigation, at the rate of 7 miles per hour,	12·97
56.50 miles of lake navigation, at the rate of 11 miles per hour,	5·14
Passage of 28 locks, at the rate of 20 minutes per lock,	9·33
Total,	46·27

say two days.

Time occupied by Sail Vessels.

47·09 miles of canal navigation, at the rate of 2 miles per hour	23·54
147·30 miles of river and lake navigation, at the rate of 4 miles per hour,	36 82
Passage of 28 locks, at the rate of 30 minutes each,	14·00
Passage of 8 locks by steam-tugs, at the rate of 20 minutes each,	2·67
Total number of hours	77·03

or, say 3¼ days.

The establishment of lights at several points on the river, and at the cuts on either side of the lake, in addition to those required at the locks, will be indispensable to a practicable navigation in time of night.

The improvement of rivers above tide water, for purposes of navigation in connection with that of inland canals of ordinary dimensions, is, except under peculiar circumstances, regarded with disfavor. The objections to adopting the channel of a river as part of a canal, arise mainly from the presence of a too great current in time of flood, and the difficulty and expense attending the repairs of the mechanical structures connecting the inland with the river portions of the navigation. On the San Juan river the former will, to a great extent, be remedied by the large increase of volume produced by the dams on the river below.

In cases of substituting rivers for inland canals of large dimensions, where high dams are practicable, the double advantage of saving the expense of constructing a large prism, and of avoiding excessive currents, is attained, and the navigation of the river portions with steamers, and with sail vessels tracked by steam-tugs, would be more practicable; these advantages will, to a very great

degree, be realized by the adoption of this river upon the plan projected; although the substitution of an inland canal might by some be considered practicable, the expense, owing to causes already stated, would be very great.

It is to be admitted, that high dams are more liable to failure than low ones; the failure, however, in the cases under consideration, being so much reduced by the elevation of the river below them, by succeeding dams in all of the cases of earth foundation, excepting No. 7, very much tends to their security. With the proper precautions in constructing the latter, and ordinary care in the others on the plan proposed, it is believed that these dams can scarcely be regarded as liable to the contingency of serious failure.

Upon that canal, the effects of frost, an agent the most destructive of masonry and other parts of the canals in this country, and to which a large proportion of the sudden breaches that occur may be attributed, will not be experienced; and so far as known, all of the conditions connected with permanency and uninterruptad navigation will be much more favorable than would attend a canal of the same dimensions and character of workmanship, located in this country.

The instructions of your board require the survey and estimates to be for a canal of sufficient depth for vessels of the largest class.

(To be continued.)

IRON MANUFACTURES IN GREAT BRITAIN.*

FIRST PAPER.

By R. H. Thurston, Eng. U. S. N., Assist. Prof. Nat. Phil. U. S. N. A. Member of the Institute.

Iron shipbuilding, though an art of but little more than a quarter of a century's growth, has become one of the most important branches of British industry, and an essential element of British commercial supremacy.

The advantages of iron over wood as a material for ship construction are so marked and have now become so well understood, that it cannot be long before wooden hulls will have become entirely superseded wherever iron can be cheaply obtained.

Some of these advantages are, greater strength and durability than can be obtained in wood; less weight of hull by, probably, 15 to 25 per cent., as the iron is of less or greater strength; greater facilities for thorough repairs and periodical inspection of every part; greater safety from the admission of transverse bulkheads, and, in

* A professional tour occupying a few weeks of the past summer has furnished a mass of memoranda, from which the material of the following article has been gleaned.

large vessels, the cellular structure of bottom; less liability to general breaking up when wrecked, and less danger from fire. The fine lines that can be obtained in iron, without impairing the strength of the structure, specially adapt iron vessels for screw propulsion; the ease with which an iron war-vessel may be laid up, and her freedom from deterioration for an indefinite period, are most important advantages where the larger proportion of the vessels of a navy are never employed, except in time of war.

All European nations have learned to recognize these advantages; and, in the United States, iron shipbuilding is gradually assuming its rightful position, notwithstanding the cheapness of timber.

The disadvantages of rapid fouling in warm climates, and of the deviation of the compass from local attraction, although less formidable than at an earlier date, are still serious evils. Some one of the numerous paints and other expedients that are almost daily proposed, will probably be found to prevent fouling of the bottom; and the laws governing the magnetism of ships are becoming so well known that this evil is rapidly becoming insignificant.

It can hardly be doubted that, in the United States, the screw colliers recently built of iron on the Delaware, are the pioneers of a large fleet of iron coasting vessels, and that iron steamboats are, sooner or later, to exhibit their special advantages on our western rivers, as the only vessels in which a strong hull can be obtained with light draught of water. It is to be hoped that the value of iron will be soon as well recognized in the United States as it is already in Great Britain.

A very considerable part of the iron shipbuilding of Great Britain was formerly carried on in the neighborhood of London, and near Liverpool, but, after sharp competition, the builders in the North of England, and in Scotland, have almost entirely absorbed the business.

On the Thames, scarcely any of this work is now done; but a very good business is still done on the banks of the Mersey, several firms being established there.

At Lairds' establishment, Birkenhead, nearly all of the five stone docks and four slips were occupied, at the time of our visit, either by new vessels, or by steamers taken in for repairs; they were not, however, employing their full complement of 2,500 men. There may be seen here an unusually fine collection of models, represent-

ing vessels constructed here: among them some of the finest ships in the British navy and mercantile marine, and a considerable number of vessels built to foreign order.* Among the latter was pointed out the graceful model of that costliest of all ships, the "Alabama."

Builders on the Mersey enjoy the advantage of obtaining their coal and iron from the neighboring collieries and mines of Lancashire, and are, therefore, quite well prepared to compete with builders in other parts of the Kingdom: labor is rather expensive.

On the Tyne, the largest establishment is that of the "Palmer Shipbuilding Company," at Jarrow, a few miles below Newcastle. Here may be seen the reduction of the ore in their four great blast furnaces, the puddling and rolling of the iron, and all other processes up to the completion of the iron ship and all of its machinery and fittings; the whole establishment employs about 6,000 workmen. We found here nearly a dozen steamers, in all stages of progress. Several were screw colliers, plainly finished, and of low steam power, but well put together and capable of doing good service; another was a fine large steamer for the Guion transatlantic line, a vessel of beautiful lines, great strength and high power; still another was the British iron-clad "Triumph," since launched. This vessel, like a sister ship, the "Swiftsure," which was some time since completed by the same firm, is 3,892 tons register, 280 feet between perpendiculars, 55 feet beam, 36½ feet from spar-deck to keel; 6 inches of armor is carried over a 10-inch teak backing and 1¼ inch inner skin; the battery is in a central casemate; the bow is shaped and strenghtened to be used as a ram. The machinery is built by Messrs. Mandsley & Field, of London; the steam cylinders are 80 inces in diameter, with 4 feet stroke of piston, and steam jacketed; these engines are of the common style direct-acting, fitted with surface condensers, and the steam is furnished by boilers with horizontal fire-tubes. These ships have lifting screws, and carry a large spread of canvas. A peculiarity in the construction of the "Triumph" is the wooden planking covering the iron skin plating below the water-line, which is intended to be coppered over like any wooden ship.

On the Wear and the Tees, and other northern English rivers, shipbuilding is carried on extensively; but by far the busiest spot in Great Britain is found on the banks of the Clyde, near Glasgow. Messrs. R. Napier & Sons, J. & G. Thompson, John Elder & Co.,

* H. M. S. Captain was built by Messrs. Laird; *vide* Jour. of the Frank. Inst., No. 5, Vol. LX.

Tod & McGregor, and other well-known firms, are established here, and almost line the banks of the river from Glasgow to Govan.

During the first ten months of the last year, 156 iron vessels have been launched here, with a total of 144,200 tons burden; during the corresponding months of 1869, the number of vessels was 180, and of tonnage 160,000.

These vessels are almost exclusively steamers, and vary in size from 1,500 up to 3,000 tons register.

The cost of the cheaper class of vessels, capable of making eight or nine knots under steam, is about £16 per ton; of moderately high powers, steamers for passenger lines, £22 to £25; and of first-class passenger steamers of high speed, fine finish and extra fittings, £30 per ton, and even higher.

The systems of work in this and other shipbuilding districts of Great Britain differ slightly in matters of detail, but in all dimensions builders are, everywhere, generally governed by rules approved by either Lloyd's or the Liverpool Committee.* Occasionally, however, purchasers who are able to act as their own underwriters, prepare their own specifications, and, as a rule, obtain even stronger hulls than the rules produce.

The iron put into English and Scotch ships is not usually of the best quality of even British iron, and British ships are not, therefore, as strong as they should be with hulls of such weight; but the workmanship is generally good, and the disposition of butts, and the method of fastening, are such as make the best possible use of the material in respect to strength of structure.

The iron used in Glasgow ship-yards is Scotch iron, made in the neighborhood, and is obtained at prices that are low in comparison with those paid in the South of England. The cost of labor is also very greatly in favor of Scotch builders, the difference between wages here and on the Thames being stated by some builders as from 30 to 35 per cent. The contrast between the activity seen on the Clyde and the quietness on the Thames is, therefore, readily accounted for, and it can hardly be expected that southern competition can again be successful, now that the one necessity that was formerly lacking in the North, skilled labor, is readily obtained.

The most extensive establishment on the Clyde is, now, that of Messrs. John Elder & Co., the "Fairfield Works." Here we found

* For particulars, consult "Shipbuilding in Iron and Steel." By E. J. Reed, C. B., Chief Constructor of the Navy; London, John Murray 1869, an admirable work.

nine steamers on the blocks, and several others were either afloat and proceeding rapidly to completion, or were ready to be laid down as soon as room could be made for them. Work is done here rapidly and well, and the crowded state of their yard indicates that they are fully sustaining a long-established and well-earned reputation.

The "Italy," of the National Line, was recently set afloat by this firm. An inspection of the steam log of one of her earliest voyages between Liverpool and New York, shows her to have made the run with perhaps the heaviest cargo ever carried across, in twelve days, on less than fifty tons of coal per day; the mean indicated horse-power for the trip was about 2,000. This was, certainly, a very excellent performance for a ship registering 3,700 tons, and proves the vessel to have a fine form as well as excellent machinery.

Messrs. J. & G. Thompson were building two steamers of large carrying capacity, and of moderate power, for grain transportation; they have a square, full midship section, but neatly drawn lines fore and aft, and are expected to steam nine knots per hour. Two steamers for a mixed traffic, carrying both passengers and freight, were also well along, and others were afloat and nearly ready for their owners. Messrs. Thompson built the "Russia" and other later steamers for the Cunard Line, and the fact is a strong testimonial in their favor. About 2,000 men are employed in the engine-shops and shipbuilding yards of this firm.

Messrs. R. Napier & Sons, and the other firms of the neighborhood, were moderately well supplied with work, and all appeared to anticipate a still further increase of business. The Napiers have long been well-known as one of the few firms to whom the English government has been accustomed to entrust public work. They have recently completed the "Hotspur," a peculiarly designed iron-clad, for the British navy. This ship is intended to be formidable as a ram, and has powerful engines, twin screws, and carries very little canvas; the side armor is from 8 to 11 inches in thickness, and is carried forward to the stem in such a manner as to greatly strengthen the bow; the single heavy gun is carried in a pear-shaped casemate; the ship is of 2,637 tons register. Among merchant steamers, the "Ville de Paris" and "Periere" may be mentioned as fine specimens of Messrs. Napiers' work.

In all yards visited, the keel was laid in the plane of the magne-

tic meridian, with the stem toward the south; the magnetic character assumed by the ship is therefore exhibited by Fig. 1, where N S is the line of dip of the magnetic needle, and E W, the neutral line of the ship; the shaded portions have a north, and the unshaded part a south, polarity.

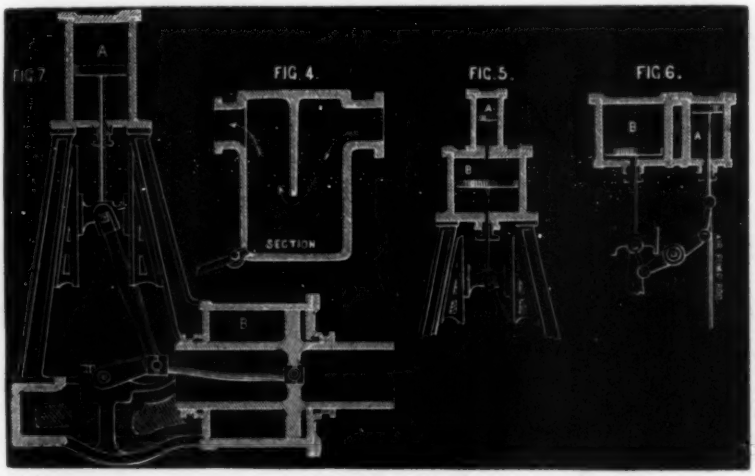
An iron ship usually acquires, while building, a strong magnetic character, and as a considerable loss of magnetism generally occurs in the first heavy weather that is met with, the first voyage of the ship occasions some anxiety, but the magnetism soon becomes much less in amount and nearly permanent in character; the compensation of the compass may then be effected, or a revised table of errors constructed, and the ship's course can be laid with perfect confidence.

In the examination of this subject, the magnetism of ships and the deviation of their compasses by local attraction, Scoresby, Bar-

low, Rundell, Evans, Airy and a few other theoretical and experimental investigators have rendered the world a service that will never be fully appreciated. Through their labors the compensation of the compass has become comparatively simple, the differing effects of the induced and permanent magnetism being now quite readily distinguished and easily compensated separately.

In the machinery of steam vessels, important changes have occurred within a few years, in consequence of the imperative demand for economy of fuel and space. The pressure of steam carried in marine boilers, has gradually risen with a corresponding increase

in the extent to which expansion is carried, until some of the leading British marine engine builders have introduced boilers in which the pressure of steam is kept at 75 pounds per square inch, and engines in which it is expanded from five to ten times. In some cases, even higher steam and greater expansion has been adopted, Mr. J. M. Rowan, of Glasgow, having run up to 120 pounds and more, per inch, expanding more than 15 times.



The adoption of such high pressures and great expansion in the marine engine, where regularity of motion cannot well be insured by the use of a fly-wheel,* has compelled a radical change in the form of engine. Messrs. Maudsley, Sons & Field attempted, some time since, to introduce an engine in which three cylinders were coupled to cranks set at angles of 120° with each other, but we were informed by a member of the firm that their cost prevented their becoming a commercial success, although quite satisfactory in regard to economy of fuel, and we found that firm, like nearly every well-known firm in the kingdom, building "compound engines." Perhaps the only exception to the rule is that of Messrs. Penn & Sons, who have the finest establishment for the manufacture of marine engines in Great Britain; they still build the trunk and oscillating engines for which they have long been celebrated.

Surface condensation is now universally adopted.

* At least one English line (of China steamers) has adopted a single cylinder engine with fly-wheel, with, it is stated, satisfactory results.

The boiler used for generating high steam is usually very similar to the one shown in Fig. 2. A cylindrical shell of about 7 feet diameter and a thickness of from $\frac{3}{4}$ to $1\frac{1}{4}$ inches, according to the amount of steam carried, is built with two and sometimes three large cylindrical flues, in which are the grates, and above them a set of horizontal "fire-tubes," of about 3 inches diameter and from 6 to 8 feet long, through which the gases return to the front and thence rise into the "funnel." This boiler is strong, of moderate cost, generates steam freely and economically, and occupies comparatively little space. The riveting is performed by a steam riveting machine, wherever possible, butt joints being usually adopted, and the work looked generally strong and neat. The ends of the boiler are strongly stayed, and the tube sheets are stiffened with stay tubes with thin nuts at each end. The flues are often strengthened by ⊥ rings at intervals, and another method, which, however, is oftener seen in land boilers is shown in Fig. 3.*

Between the boilers and the engines, a "spray collector" or "separator," of the form shown in Fig. 4 is often placed, even when the steam has passed through superheating tubes.

In the design of engines, a great variety is noticed, as every builder has his own peculiar style, for which he claims special advantages, but we usually find a general resemblance to the old Woolf engine of seventy years ago.

In the engines built by Messrs. Maudsley & Field, the small high pressure cylinder, A, is placed upon the large cylinder, B, Fig. 5, both having a common piston rod, and two such pairs being usually coupled to cranks set at right angles. This arrangement is very convenient, also, in altering old engines.

Messrs. Elder & Co., formerly Randolph, Elder & Co., who are probably entitled to the credit of having, many years ago, and in the face of immense opposition, been pioneers in the adoption of high steam and considerable expansion with the compound engine, usually so arrange the high and low pressure cylinders that their pistons move in opposite directions, coupling two pairs to the crank shaft.

By this arrangement short passages are obtained between the cylinders and a simple form of valve-gear. The opposite movement of the pistons is sometimes obtained by placing the two cylinders of a pair in the fore and aft line, coupling their rods to cranks set on the crank shaft at 180° apart; in another and less expensive

* This method of strengthening flues was proposed for "Cornish boilers" by the writer some years ago, but purchasers generally preferred to accept a weaker boiler at less cost.

arrangement, one cylinder, see Fig. 6, acts directly upon the crank, while the other, which is placed at one side in the athwartship line acts upon the crosshead of the first through a "sway-beam" to the end of which the crosshead is coupled by a short link.

In still another style of engine, the two cylinders are coupled to cranks set at angles of 130° or 150°, thus securing a pretty nearly opposite movement of pistons, and yet allowing the engines to turn their centres easily, without the assistance of a pair of right angles.

The "Palmer Shipbuilding Co.," and, we believe, one or two other firms, are building still another form of engine, see Fig. 7. In their engines, the high pressure cylinder, A, is placed directly above the crank-shaft in the usual manner, but the low pressure cylinder, B, is mounted horizontally and athwartships, and is coupled to the same crank, the piston of one being thus at half-stroke, when that of the other is at the end of the stroke. The pipe connecting the two cylinders and the steam jacket of the large cylinder form together a large reservoir, into which the small cylinder exhausts and from which the large cylinder takes its steam, and excessive irregularity of steam pressure is thus to some extent avoided.

In still another and favorite design, the same action of the steam is obtained with a pair of cylinders side by side, coupled to cranks set 90° apart, instead of by placing the cylinders at angles of 90° with each other.

In this, as well as the preceding style of engine, it is, of course, necessary to provide a small pipe leading steam directly from the boiler to the large cylinder for use when starting. All these forms of engine have been found to give excellent results when well taken care of. The Palmer Co. use the Corliss valve, but not the Corliss cut-off apparatus. All makers steam jacket one, and often both cylinders.

From our own experience and from data gathered from many sources, we should judge that a well built engine of the ordinary single cylinder type, with jet condenser, steam at 30 pounds pressure, and expanding about three times, can be expected usually to work with a consumption of 30 pounds of steam per horse-power per hour, with surface condenser, the same engine should consume less than 25, while the best specimens of the compound engine are reported, with 60 pounds pressure and upward in the boilers, expanding six or eight times, to use 15 pounds of steam or less. Prof. Rankine reports in his "Steam Engines and Prime Movers" that the "Thetis," compound engine consumed but about 10 pounds of steam per horse-power per hour. This was, perhaps, hardly more than an approximation, but the engine was built by Messrs. Rowan & Co., of Glasgow, and steam entered its cylinder with an initial pressure of 108½ pounds per square inch, expanding fifteen times.

We are prevented by the length to which this paper has already extended from entering into an analysis of the theoretical and practical advantages and disadvantages of the compound engine, and it may more properly form the subject of a separate paper.

The accompanying table may be of interest in this connection.

Dimensions of Recently Built Steam Vessels.

Engine Builders.	Steamer.	Dimensions of Hull.	Style of Engines.	Size of Cylinders.	I.H.P.	Steam pressure.	Coal. Per I.H.P. per hour.	Speed, knots per hour.	Date.
R. Napier & Co.....	"Periere.".....	339′ × 43½′ × ?	Vertical direct.	2—84″ × 4′	2500	30	3·1 lbs.	14·15	1869
J. Elder & Co.....	"San Nanzing."...	225′ × 32′ × 23¼′	Comp.	2—38″ } 2—76″ } × 4½′	930	50	2.17	36 5	1870
.....	U. S. B. M. S. Briton....	....	Comp.	57 ″ } 104½″ } × 2¾′	2148	58	1·98	.....	1870
J. Penn & Co.....	H. B. M. S. Hercules.	325′ × 59′ × ?	Trunk.	trunks 48″ 127″ × 4½′	7185	30	2·53	13·39	1869
W. Simons & Co.....	"India.".....	311′ × 36′ × 23½′	Comp.	2—36″ } 2—72″ } × 3′	.....	...	33 tons per day.	11·47	1869
Tennant & Co.....	"Irene.".....	252′ × 30′ × 19′	Comp.	31″ } 56″ } × 3′	517	60	2·15	.....	1870
A. & J. Inglis.....	"Shantung.".....	215′ × 39′ × 24¾′	Vertical direct.	2—46″ × 3′	890	23	2·01	10·08	1870
Maudsley & Fields...	"König Wilhelm."	365′ × 60′ × ?	Horizontal direct.	3—95″ × 4½′	8664	30	2·56	14·5	1869

U. S. Naval Academy, Annapolis, Md , October, 1870.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

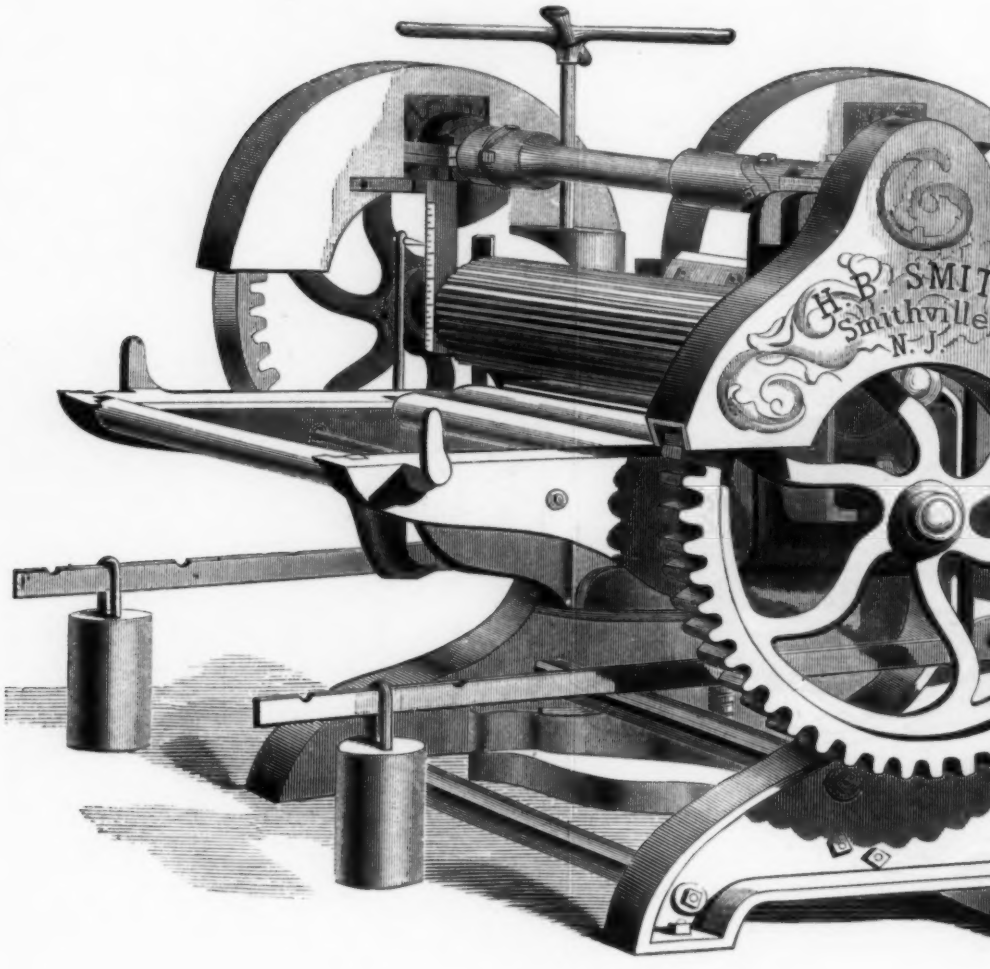
(Continued from Vol. LX., page 392.)

Surfacing Machines.—Surfacer has become the technical name for planing machines that are used to thickness, and dress the surfaces or flat sides of lumber. Machines of this kind were, in the first article on planers, alluded to as "surface gauging planers," and are the popular machines in this country for all kinds of planing that can be done in this manner, and for some planing that perhaps should be done on other machines. The surfacing machine, consisting of a single, or with two cutting cylinders, were called into use mainly by the peculiar nature of the lumber business in this country. The rapidity and cheapness of their work adds but little to the worth of lumber to surface and reduce it to a unifo m thickness, in which state it is lighter and cheaper to transport, easier to cut and work, and is ready to receive paint for out-door uses. A first-class surfacing machine, when properly fitted, and strong enough, will dress from two thousand to three thousand feet per hour, of pine boards, on one or both sides, at but a trifling cost—the machine furnishing an excess of fuel over what is needed to drive it, and requiring no skilled care except to dress the cutters.

The feeding mechanism of surfacing machines should consist of three pairs of strongly geared rolls, having an elastic pressure, that can be readily controlled or changed. The bed beneath or opposite to the cylinders should be strong and firm, without any chance of yielding from the action of the cutters. They should be of some hard material, to prevent wear, which is very rapid with "gritty" lumber. Machines with a movable bed, consisting of slats or bars, mounted with links, forming an endless chain, have been introduced in this country for the rougher class of work. The endless table or platen passes over a fixed bed, carrying the lumber under the cutters by the friction on its top surface. The advantages of this arrangement are mainly in the cheaper first cost of the machine, and in obtaining a reliable feed without the expanding gearing that is necessary in the roller-feed arrangement. They are, however, liable to wear out rapidly, from abrasion under the movable bed and the numerous joints and rivets of the chain has deterred most makers from adopting it.

The engraving, Plate V, illustrates a roller-feed surfacing machine, from the designs of the manufacturer, H. B. Smith, of Smithville, N. J. The arrangement of the machine is very clearly shown, and will require no description to be understood by those familiar with this class of machines.

Fig 1 is a side elevation from the designs of Messrs. Allen Ransome & Co., of London, England. The design shows vertical spin-


H. B. SMIT
Smithville
N. J.

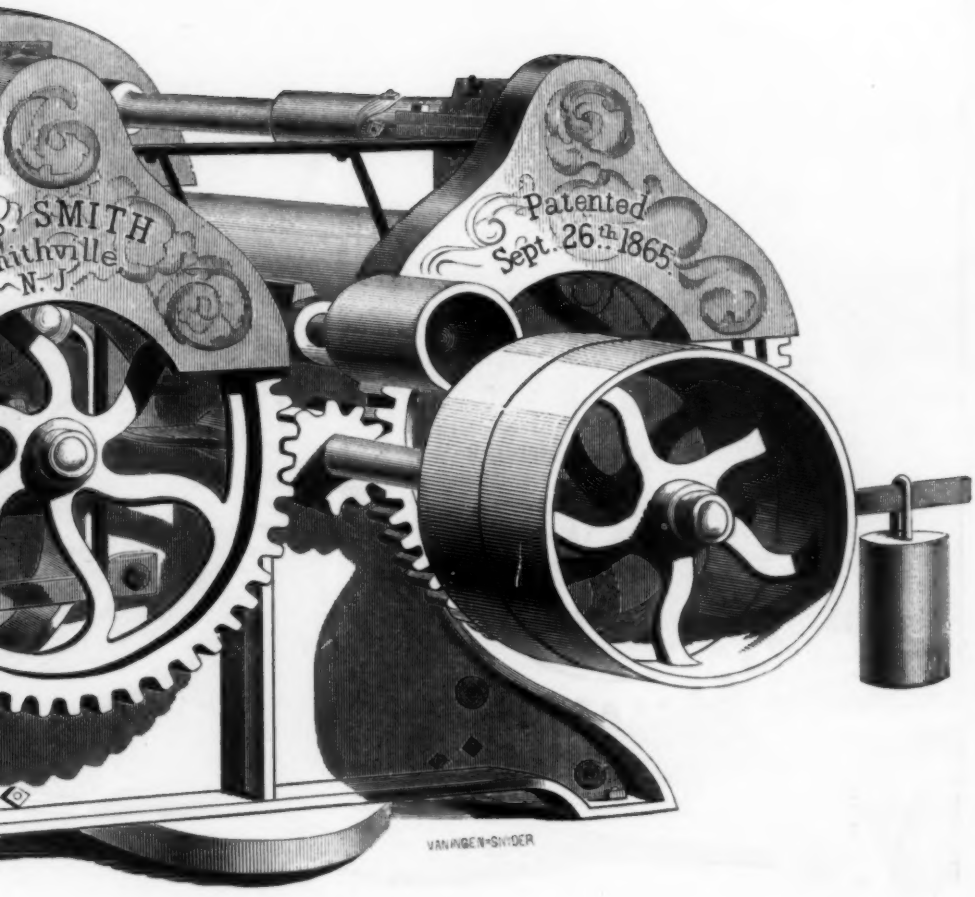
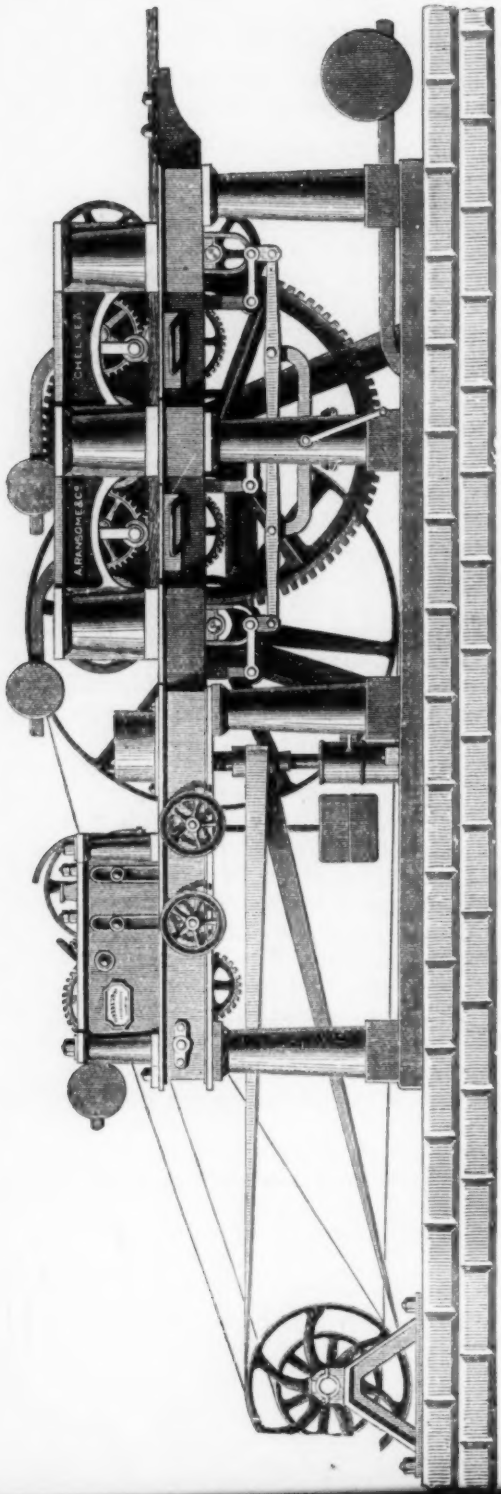

SMITH
ithville
N. J.
Patented
Sept. 26th 1865
VAN INGEN & SNYDER

Fig. 1.

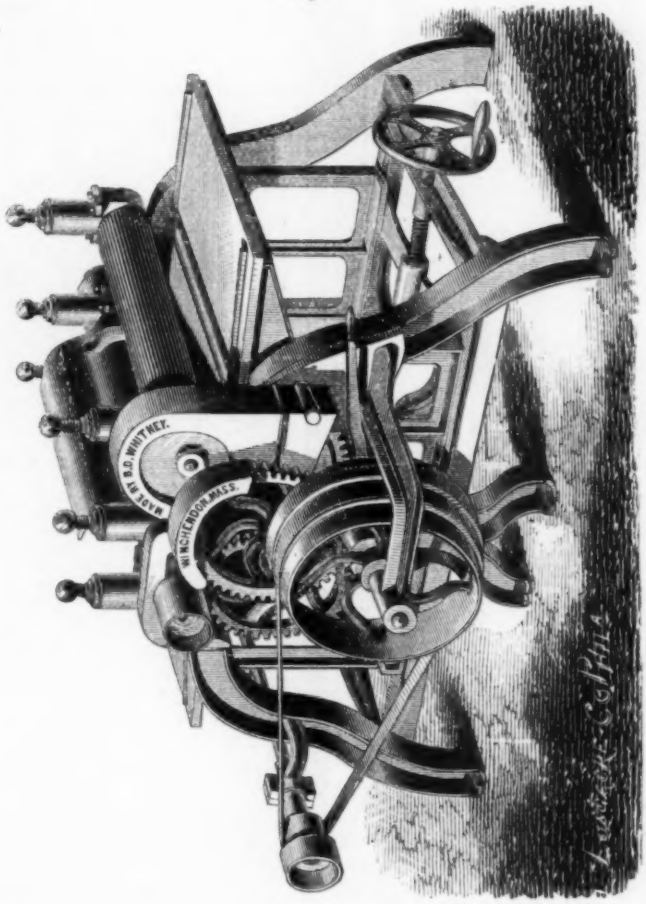


dles for matching, or side dressing, but is adapted to plain surfacing. The lumber is first reduced with rotary cutters, then acted upon by fixed cutters to produce a smooth surface. The application of fixed cutters in wood planing machines with a direct edge, as in the common hand plane, is a subject that deserves a thorough investigation by manufacturers of wood machines in this country. Their extensive use in England and on the continent, unless there is some great difference in the conditions of lumber dressing, would argue their importance for many uses here. The writer hopes, at some future time, to present, through the *Journal*, some views on the matter, and would be obliged by any communication bearing upon the subject.

The machine illustrated is drawn ½-inch to 1 foot, weighs about 5 tons. The medium rate of feed is 45 feet per minute, working from one to three sides of the lumber at a time.

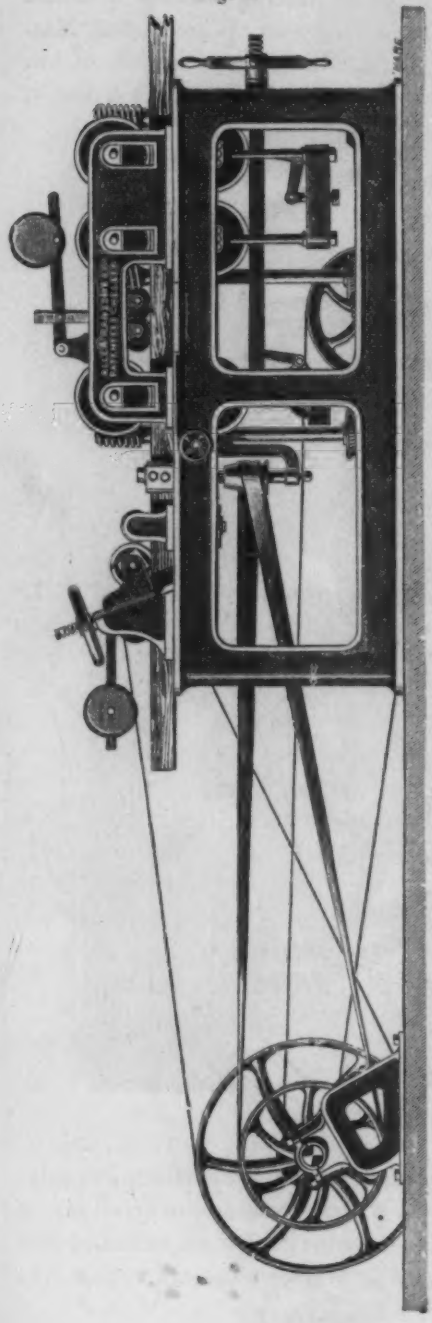
Fig. 2 it a perspective elevation of a surfacing machine from the design of the manufacturer, B. D. Whitney, of Winchendon, Massachusetts. We cannot refrain from calling the attention of our readers to the artistic merit of the engraving by Longacre & Co., of

Fig. 2.



Philadelphia. Although in perspective, the proportions and relations of the parts are clearly defined with an exactness of detail rarely attained in cuts of this kind. This machine has had an extended sale throughout our country, there being at this time more than five

Fig. 3.



hundred in use. It has several peculiar features, which we here notice. The bed is movable, and rests on inclined planes, giving it continually a solid bearing at all points of adjustment. The cylinder and upper feeding rolls are fixed; that is, they have no adjustment for varying dimensions. The lower rolls are geared expansively with the top rolls by a peculiar arrangement of wheels, which could not be illustrated without diagrams. The cylinder is of steel, and, contrary to the popular theory for smooth planing is quite small in diameter. It performance at Paris. at the Exhibition of 1867, excited much comment among English manufacturers who witnessed its work, which was smooth, and almost free from the waves that are usually seen on surfaces planed with rotary cutters.

Fig. 3 is a side elevation of a planing machine from the designs of Allen Ransome & Co., London, having lighter proportions than the one shown in Fig. 1. It is arranged with horizontal and vertical spindles and fixed cutters. The framing, as will be noticed, is cast in one piece, and the whole strongly fitted, and capable of hard service.

MAP OF THE ISTHMUS OF DARIEN.

By JOHN C. TRAUTWINE.

THE accompanying map of the Isthmus of Darien is a reduction from one on a large scale, carefully prepared by myself, for my own use. The coast lines are chiefly from British Government charts. The river Atrato is laid down from my own personal survey of that stream, in 1852.

The route surveyed in 1858, by Lieutenant, (now General) N. Michler, U. S. Engineers, for an interoceanic ship canal, has been reduced from the large maps which accompany his Report. It will be perceived that the engraver has inadvertently changed the position of some of the words which indicate the position of this route Thus, the words "ship canal" should have been in a nearly straight line, just above the 7° of latitude. The survey terminated, on the Pacific side, at the little bay of Paracuchichi. It followed the line of the small stream called the river Truandó for several miles. General Michler proposed to unite that stream with the Atrato by a cut shown on the map by a dark, straight line. His summit, near the Pacific, was about 948 feet above mean tide, and at that point he proposes a tunnel, four miles long. Just south of General Michler's route is one proposed for the same purpose by myself some years before, or in 1852. I consider it a matter of regret that it was not surveyed in preference to the other route, inasmuch as the distance is shorter, and the Bay of Cupíca affords (according to Admiral Fitz Roy) an excellent harbor; whereas such is not the case at Paracuchichi. Indeed, with the exception of Cupíca Bay, there is no harbor along that section of the Pacific coast. The Atrato, by my own soundings, affords at least 36 feet of depth, up to Vigia Curbaradór, at which point my suggested line begins. Above Vigìa Curbaradór, which place consists of but two or three huts, the depth of the Atrato diminishes greatly, in consequence of the second channel, called the Caño Tadiá. This cáño extends about 30 miles, when it again unites with the parent river, near the mouth of the river Napipí. The Napipí has been much spoken of as a route for a ship canal, chiefly owing to suggestions to that effect by Humboldt. But I found it to be nothing but a small shallow creek, extremely circuitous, and altogether unadapted to that purpose. Moreover, the shallowness of the Atrato from the mouth of the Napipí to Vigía Curbaradór, precludes all idea of

using the Napipí as a canal for large vessels. Extensive marshes, frequently overflowed, border both sides of the Atrato, almost to its very head, and would render the construction of a permanent canal through them an expensive undertaking.

The great bend in the mountains of Espiritu Santo, west and southwest of the gulf of Darien, is given from my own observations, made when ascending the Atrato in 1852. The ridge seen near the Pacific coast, between latitudes 6° and 7¼°, attains a genral height of 1000 feet.

The map shows what is known of the country between Caledonia Bay on the Atlantic; and the Gulf of San Miguel, on the Pacific; including the river Chucunaqué, the scene of the sufferings endured by the U.S. Surveying party, under command of the gallant officers, Strain and Truxton. The late efforts of the United States surveying parties, under Commodore Selfridge, have been directed to routes from Caledonia Bay, southwestward, towards the river Savana, which empties into the Gulf of San Miguel. Also, to routes from the Gulf of San Blas, on the Atlantic, southwardly, to the river Chepo, or Bayáno, which enters into the Pacific. The general physical character of the country along all these routes may be inferred from the map. This, however, gives no idea of the difficulties, privations and dangers to be encountered by parties surveying in those wild, inhospitable regions.

A perfectly practical route for an interoceanic railroad can be had by leaving the Atrato at the mouth of Caño Cacarica; thence following along the north side of said caño, to near its head; thence turning southwest, rising along the mountain slopes to where Gen. Michler crossed the ridge, near lat. 7°, long. 77° 36′; and thence descending to Cupica Bay. This route would be about 100 miles long; and the grades need nowhere exceed about 40 feet to a mile, even without a deep cut or tunnel at the summit. With a tunnel two miles long through the ridge at or near Michler's summit, the maximum grade will be reduced to 15 or 20 feet per mile.

Though the engraving does not possess the spirit of the original; still, the map will be of interest at this time, when the attention of the commercial world is being so strongly directed to the subject of an interoceanic ship canal.

ENGINEERING OF THE PERIOD.

By Wm. M. Henderson, Hydr. Engineer.

(Continued from Vol. LX, page 384.)

We pass on to another remarkable invention, emanating from Harrisburg, Pa.—a simple apparatus for raising water from mines, quarries, &c., particularly recommended, we are informed, for water works. It is composed of two receivers. A single receiving pipe proceeds to the water, branched at its upper end, to the lower end of the receivers, and, continuing upwards, serves as the rising main. These pipes are fitted with suction and discharge valves, similar to a pump; steam is introduced alternately to each receiver. The *modus operandi* is, first, to fill one of these receivers with steam; the communication between it and the steam boiler is then shut off, whereupon the steam condenses, and a partial vacuum created, the atmospheric pressure upon the surface of the water in the well forces a portion up the receiving pipe, and so charges that receiver with water; steam is then re-admitted to the surface of the water and drives the charge up to the point where the water is required to be elevated. The steam connections are so arranged that the operations of charging and discharging are performed alternately, so as to keep the supply as continuous as possible.

The reader will perceive this is, to all intents and purposes, the identical invention of Captain Savery, who obtained a patent for it in the year A. D. 1698. There is no doubt that he received the first idea of this engine from the fire engine described in 1633 by the Marquis of Worcester. Savery's engines, however, were not automatic, but required a laborer to manipulate the cocks. It was reserved for M. de Moura to add a self-acting apparatus for this purpose. Papin introduced a movable disc or float, which was interposed between the water and the steam, to lessen the tremendous loss from condensation which occurred whenever the steam was admitted for expelling the water. This description of engine received the finishing touches from Pontifex, who left nothing further worth improving.

The principal objection to this form of engine, we are told, was found to arise from the great consumption of fuel, a considerable portion of the caloric employed in the generation of the steam being absorbed in heating the new surface of the cold water last raised from the well, and when the water was required to be elevated to

CARIBBE
Point Manzanilla
Punta Escondido
Porto Bello
GULF OF SAN BLA
ASPINWALL
Chagres
R. Gatun
Gatun
R. Trinidad
PANAMA R.R.
R. Chagres
R. Obispo
Escudo de Verágua
Rincon Point
PANAMA
Chepillo I.
R. Taimito
Taboguilla
Taboga
Chame I.
CHAME BAY
Point Chame
Otoque Banks
PEARL
ISLANDS
Pedro Gonzales
Is. del Rey
San Joseph or Churche I.
R. Tuira
PARITA BAY
BAY OF PANA
Point Liso
Cebaco I.
Otoque I.
Pope Mala
Q. Los Frailes
Venado Is.
Point Pinreos
Manito Point
PACIFI
SCALE OF LAND OR STATUTE
MAP
OF THE
ISTHMUS OF DARIEN
compiled from the best Authorities
BY JOHN C. TRAUTWINE CIV. ENG
PHILADELPHIA 1870
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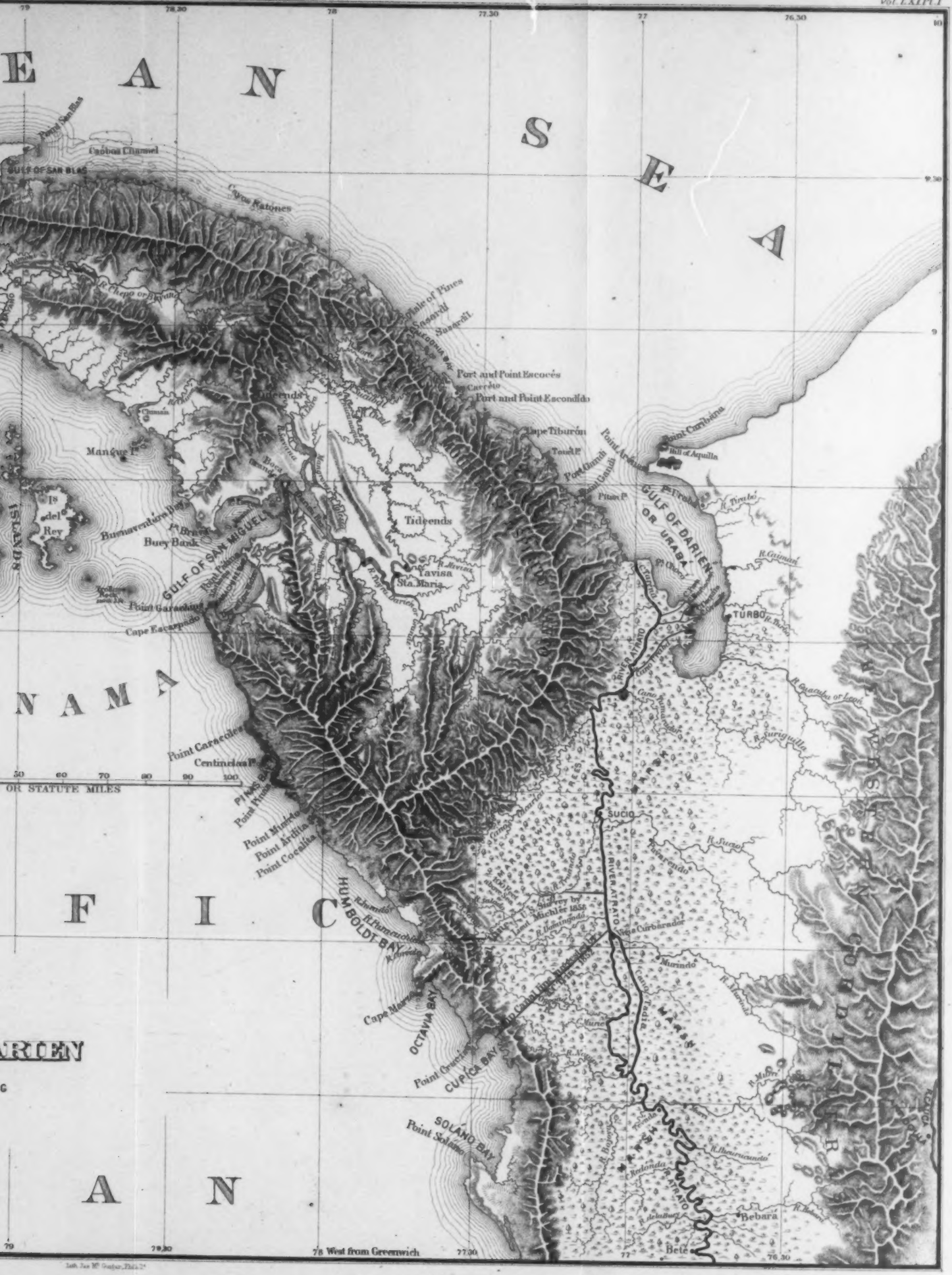

E A N
S E A
Caobon Channel
GULF OF SAN BLAS
Cayos Ratones
R. Chepo or Bayano
Port and Point Escocés
Port and Point Escondido
Cape Tiburón
Point Arboletes
Point Cumbrera
Bahia of Aquilla
Mangue P.
Ids. del Rey
Burnaventura Bay
Pt. Brava
Buey Bank
GULF OF SAN MIGUEL
Tideends
Yavisa
Sta. Maria
Point Garachine
Cape Escarpado
GULF OF DARIEN OR URABA
TURBO
R. Atrato
R. Guaimaral
R. Guacuba or Leoni
R. Turiguilla
N A M A
Point Caracoles
Centinela P.
OR STATUTE MILES
Point Mineto
Point Ardita
Point Cocalita
SUCIO
R. Suruco
F I C
HUMBOLDT BAY
Cape Marzo
OCTAVIA BAY
Point Gracias
CUPICA BAY
SOLANO BAY
Point Solano
Murindo
R. Murindo
MAANZA
R. Bebara
Bebara
A N
78 West from Greenwich

any considerable distance, there was no conceivable mode of obviating this great objection. Savery's engine was not adapted either for the supply of towns or for the draining of mines, two of the patentee's principal objects. His great expectations ended with the erection of a few small engines for raising water in the pleasure grounds of some of his admirers. Savery's engine proving a failure, the mines were only rescued from abandonment by Newcomen, who, as we have stated, shortly afterwards introduced the atmospheric engine. This engine took steam under the piston only, the down stroke being accomplished by the force of the atmosphere, favored by the vacuum produced by the condensation of the steam on the under side.

This was an important step in the history of the steam engine. Already was produced one-half of our steam engine as it exists now The rest was made short work of by the master mind of Watt, who introduced (about one hundred years ago) the feature of condensation in a separate vessel, and afterwards admitted steam to the other half of the stroke, developing the Rotative engine very much as we see it at this day.

Returning to this Harrisburg engine, we have been officially informed that, upon trial, it raised one million pounds of water one foot high by one pound of coal. This is equal to a duty of 112 millions, which, it must be admitted, is good, very good, when we take into consideration that the full amount allowed by the laws which have hitherto governed this universe has been ascertained to be but 47 millions; and this, too, based upon the supposition that the force of the steam could be supplied directly to the water in the receiving pipe, that there shall be no loss by condensation, and a perfect vacuum maintained above the column of water to be lifted without cost. It is somewhat remarkable that the duty should be more than doubled, by the addition of friction, condensation, leakage and the defects incurred from that imperfection, produced wherever machinery is employed. Captain Savery's invention has presented a wide field of action to the professional inventors of our country.

We have his scheme presented to us, in some shape, every year, sometimes with a single receiver, when it is called a *mont jue;* frequently it comes to us with a flexible diaphragm or partition, separating the steam from the water, as suggested by Papin. Under this guise we know it as the bellows pump. It is, however, the

same old thing; there is no honest chance of ever making anything out of it. That there is a field open to those who, from preference or ignorance, cannot be classed as strictly honest, there is no denying.

We have before us a pamphlet purporting to be a system of fire protection and water supply for cities and villages, advocating *Rotary pumps*. We are informed they employ orators to discourse to the multitude the great advantages to be obtained from the simple *Rotary* principle. No reservoirs or fire engines with this system are at all necessary, said system consisting principally in employing a number of rotary and single-acting plunger pumps instead of one or two double-acting forcing pumps of corresponding aggregate power. Were it desirable to subdivide the work, for any pretended purpose, surely such necessity could not have escaped the attention of pump builders generally. The system so lauded is not even new. We know situations where the same duty has been performed in a quiet way for years, it being at best but a way of doing things by halves, without any regard to that economy of working so important where the saving of fuel is a desideratum. The pamphlet is full of notices taken from country papers, written, it is presumed, by interested parties, in the most flagrant violation of all our preconceived knowledge of such ruinous things as *Rotary* pumps, high-velocity, impracticability of carrying out either the condensing or expansive principle of steam—a source of economy not to be lost sight of where anything beyond first cost or bribery for adoption is concerned. As an advertising medium to our rural friends, the wonders performed by this astonishing *system* exclude the hope of further improvement. We are gravely informed that streams turned upon the ground plowed the earth into deep ruts; heavy barrels encountered by the same, like shuttle-cocks, were carried instantly a hundred feet into the air. Even an unfortunate ex-Mayor, who unluckily placed himself under one of the streams, was raised bodily off his feet, and suspended, like Mahomet's coffin, in the air, or, like the marble that dances over a common fountain, was compelled to perform a ludicrous ride upon the seething torrent, and subsequently dashed at a distance sprawling upon the ground. If there were no other objections to this system, we think the peril in which it places human life is sufficient to make us pause before we invite such a devastating power in our midst, unless, indeed, we employ the energies of the engine against the burning edifice, and level it summarily to the ground—a matter (there is no doubt, whatever, from the description of it,) quite within the scope of this engine's capabilities.

Philadelphia Hydraulic Works, Oct. 7, 1870.

Mechanics, Physics, and Chemistry.

TWO NOTES ON THE DISPERSION OF LIGHT.

By M. Th. Ricour.

(From the Comptes Rendus of the French Academy for December 13, 1869, and January 17, 1870.* Translated by Prof. C. A. Young, Ph. D.)

Experiment has demonstrated that the vibrations of sound are transmitted through air with a velocity independent of its pitch; luminous vibrations are also propagated in free ether with a velocity independent of their wave length. A red ray and a violet emitted at the same instant by a star reach the eye of the observer at the same instant, however great the distance traveled. It is no longer so when light penetrates transparent bodies. The rays of different wave length are then transmitted with velocities decreasing from the red to the violet, and we designate by the name of *dispersion*, this property of transparent bodies which is specific for each substance.

It is owing to this dispersion that a beam of white light is spread out into a spectrum in passing through a prism.

The note which we have the honor to present to the Academy aims to exhibit both the cause of dispersion and the very simple law which governs it.

In the first part of the memoir we establish by considerations in some degree elementary an equation of oscillatory movement for a plane polarized wave, taking account of the fact that all bodies are composed of molecules placed at finite distances from each other, we assume that in a crystallized body all these molecules are of the same magnitude, and regularly distributed in such manner that between two parallel equidistant planes there is always the same number of molecular systems, (*i. e.*, the crystal may be divided into strata by a series of parallel planes at certain equal small distances in such a way that the constitution of any one stratum shall be identical with that of any other.—*Trans.*)

* The memoir of which these notes give an abstract was referred to a committee composed of MM. Bertrand, Serret and Fizeau. Their report upon it has not yet appeared, nor the third note which he promises in the conclusion of the second. Of course it is impossible to judge from his abstract whether his memoir really makes out all he claims, and I should like much to see the report of the Committee before endorsing his conclusion.

Developing into a series this equation of oscillatory movement, we can obtain the formula of Cauchy by a first approximation limited to the two first terms of the development.

Instead, however, of proceeding in this manner by approximation, we determine directly the general term of the complete integral and obtain a rigorous expression for the velocity of propagation of a wave of given length. The problem of the dispersion is thus solved for homœdric crystals.

The formula we obtain is the following: $\sin. \frac{R\alpha\pi}{l} = \frac{\rho\alpha\pi}{l}$; in which R is the particular index of refraction which corresponds to the wave length l, and α and ρ are constants whose physical signification is perfectly determined; α is the minimum distance between two planes, parallel to the plane of the wave, and dividing the medium into strata of identical molecular constitution, while ρ is the limiting index of refraction for waves of great length, the relative position (orientation) of the plane of vibration, and the wave front being constant, ρ varies with this relative position according to known laws.

In a second part of the memoir we compare this formula with the results of experiment. Detailed tables are given for quartz and Iceland spar, whose indices of refraction have been determined by M. Mascart through the whole extent of the spectrum from the extreme red to the extra-violet. The differences between calculation and experiment (perhaps about $\frac{1}{80000}$ of the value of the computed indices of refraction) do not exceed, for the series observed by M. Mascart, the differences which exist between the results found for a given ray with different prisms of quartz by such observers as Rüdbey, Esselbach and Fizeau.

Finally, as the formula of dispersion is based upon the hypothesis of a perfect equality of the molecules, and a distribution perfectly regular, and as experiment indicates that this formula applies with great accuracy to bodies not crystallized but homogeneous, like the flint and crown glass of optical instruments, we calculate for these substances, as well as for quartz and Iceland spar, the minimum distance α between two parallel planes dividing the vibrating medium into layers of the same molecular constitution.

We thus find that this distance α expressed in ten millionths of a millimetre is equal—

For the extraordinary ray of quartz to . .	252·33
*" " ordinary " " . .	252·33 (sic.)
" " " " Iceland spar . .	300·59
" " extraordinary " " " . .	240·48
" a prism of flint glass by Steinheil . .	347·51

It is known that the wave length for the ray D is 5888·0 (in the same units.) We can thus form a clear idea of this distance a, which is closely connected with the distance between the molecules, and we see that for the substances enumerated, it is from 17 to 25 times less than the wave length of the ray D.

The absolute distance between the atoms of the ether is a very minute fraction of the distance between the ponderable molecules, and there should therefore exist in the free ether, waves much shorter than the distance a calculated for the different bodies (above named). A new law of refraction determines the transmission of these very short waves through the layers whose thickness is a, which act as true media, periodically uniform, with an index of refraction lower than that of the substance considered in mass.

These invisible waves, extremely short, form a separate spectrum which is partially superposed upon the luminous spectrum in the neighborhood of the ray A, but extends far below the extreme red where its presence is indicated by thermoscopic apparatus.

We thus establish a characteristic difference between the luminous vibrations of long period in the ultra red portions of the spectrum and the calorific vibrations whose presence in the same region is incontestable.

The formula for the dispersion gives the exact limit below A for the termination of the spectrum formed by vibrations of long period.

Below this limit every luminous vibration is necessarily excluded, but we still find extremely rapid vibrations, whose living force is considerable, and which constitute, so to speak, *pure* heat in opposition to *luminous* heat.

Portion of Second Note.

Direct experiment has proved that the wave lengths go on diminishing from A towards the extremity of the ultra violet spectrum. It has been inferred that the same law holds below A; that is to say, that the wave lengths continually increase towards the termination of the calorific spectrum. But this conclusion is unwar-

* This appears to be a mistake either of the press or pen —*Trans.*

ranted; it is a simple hypothesis not based on any direct experiment.

On the contrary, it is in opposition to the theory of dispersion, as I propose to demonstrate in the note which I now submit to the judgment of the academy, substituting for this hypothesis the indications of the theory.

The theory indicates the existence of two independent spectra, governed by distinct laws of dispersion.

The first spectrum belongs, in quartz, to waves of a length varying from $l = \infty$ to $l_0 = 1215$ (ten millionths of a millimetre.)

The law of dispersion for this spectrum is given by the formula $\sin. \frac{R\,a\,\pi}{l} = \frac{\rho\,a\,\pi}{l} = \frac{l_0}{l}$, and the values of R (the index of refraction for wave length l) are comprised between $R = \rho$ and $R = \rho\,\frac{\pi}{2}$.

The second spectrum is made of waves whose length lies between $l = 0$ and $l = 1215$, but for the most part extremely short as compared with the wave lengths of the rays in the first spectrum, and consequently much nearer $l = 0$ than $l = 1215$, this second spectrum forms by itself alone the band of slightly refracted rays, which is made manifest by thermoscopic apparatus below the limit of the luminous spectrum, and prolongs itself above this limit so as partially to cover the extreme red of the first spectrum, yet without retaining any appreciable intensity beyond the neighborhood of D.

The distinction which theory indicates between the two spectra makes it easy to understand how certain bodies are opaque, and at the same time diathermanous, while others allow the light to pass and stop the calorific vibrations. The bodies are in the presence of two orders of vibrations. One set impresses its oscillations upon the periodically homogeneous layers and causes them to move *en masse;* the other set operates upon the component atoms of the layers. There is a certain amount of independence between these two modes of vibration which explains the passage of the one and the absorption of the other.

We owe to M. Mascart an observation extremely interesting and confirmatory of the theory. In a spectrum produced by a prism of quartz, a trained eye can distinguish in the ultra-violet region, a band six or seven times as long as the ordinary luminous spectrum (from A to H). This band forms a prolongation of the spectrum,

gradually fading out towards the upper end in a continuous manner, and it is longer as the eye is more sensitive.

On the contrary, below the ray A, where the vibrations over a length equal to that of the luminous spectrum possess a living force incomparably greater than in the ultra-violet region, the most sensitive eye can only perceive a very narrow band of dull red light. This narrow band which affects the eye, is the zone in which the wave lengths increase continuously from $l=7604$ for the ray A to $l=\infty$; it has, in fact, as it ought, according to our theory, a length which is less than one-third of the length of the luminous spectrum. At the limiting point there is an abrupt termination of the spectrum formed by the longer waves, and the sense of vision is completely insensible to the vibrations of short period which exist in that region.

Summing up, then, in our first note, we have given the theoretical law of dispersion in homœdric crystals perfectly homogeneous, and have shown that the law is verified by experiment. In the present note we have established that the spectrum embraces two orders of vibration governed by different laws of dispersion.

The vibrations of long period are propagated by means of the oscillatory movement of the periodically homogeneous layers into which the medium resolves itself under the action of the ponderable molecules; these layers, limited by *surfaces of minimum elasticity*, possess a certain thickness α, which forms, as it were, the constant of dispersion for that medium.

The short period vibrations are propagated across these layers (of thickness α) in the interior of which the mean elasticity is greater than that which operates in the propagation of the longer waves.

We have established that the free ether is, in effect, able to transmit waves incomparably shorter than those of light, and we have indicated incidentally in what manner the observation of the lines in the spectra of variable stars may lead to a determination of their distance from the earth.

We have also made it appear that all known experiments confirm the theoretical views that have been set forth, and have indicated new experiments to be executed, in order to determine the lengths of the calorific waves as actually as the lengths of the luminous waves have already been measured.

It remains for us to make known the origin of these two orders

of vibrations which are propagated in the ether, and the conditions under which each attains the maximum of intensity.

It is, in fact, a general law, that all bodies, solid or liquid, emit at a high temperature vibrations of two periods extremely different, which correspond, the first order, to the maximum of intensity in the visible spectrum, the second, to the maximum of intensity of the invisible spectrum, while the vibrations of intermediate duration are, so to speak, absent, or at least possess a living force quite inappreciable.

The free ether, as we conceive, does not offer in itself, any explanation of this general law, for it can propagate with the same facility vibrations of every wave length. It is to the source of the vibrations that we must ascend; and the molecular constitution of bodies put us on the track of a rational explanation of the existence of two maxima around which, so to speak, group and condense themselves, the vibrations of the visible spectrum, and those of the invisible.

Every body is made up of *physical* molecules; every physical molecule is an assemblage of *chemical* molecules; two orders of vibrations, of widely different periods, correspond to these two orders of molecules; these molecular vibrations communicating a portion of their living force to the ether give birth to two orders of undulatory movement, constituting the radiance of light and heat. The slower luminous vibrations emanate from the *physical* molecules; the more rapid thermal, from the *chemical* molecules or atoms.

The formula which answers to these vibrations explains, at the same time, both the fusion of bodies and the dispersion of light. The developments into which it will be necessary to enter will form the subject of a third note. (This third note has not yet appeared.—*Trans.*)

Furnace Slag is utilized in Belgium by allowing it to run off into moulds along the sides of the furnace, in which it assumes the form of rectangular blocks of any size. When cold, the mass forms a compact, homogeneous slag, very much resembling porphyry, and equal, for building and engineering purposes, to the best natural stone that can be procured from the quarry.

ON THE REDUCTION OF LIGHT DUE TO THE PRESENCE OF CARBONIC ACID IN ILLUMINATING GAS.

(Read before the American Association for the Advancement of Science, Troy Meeting.)

By FRED. E. STIMPSON.

[THE experiments here detailed were made by Prof. William B. Rogers, in 1863, and a meagre abstract appears in the Reports of the British Association, at its Bath meeting, 1864, p. 40. The details have never before been published.—F. E. S.]

It is a familiar fact that carbonic acid gas is incapable of burning, and that a flame of any kind plunged in an atmosphere containing a large amount of it, is immediately extinguished. Its presence, therefore, in considerable quantity, in ordinary illuminating gas, might be expected to impair its illuminating power. But in the small proportion of one or two per cent., in which, at some manufactories, it is allowed to remain in the gas, the evil is so inconspicuous as to have led to the belief that a more complete removal of the impurity is practically of no importance.

The opinion has even been advanced, that in such small quantities, its action is merely that of diluent, serving, when present in such gas, to facilitate the combustion, to the extent, at least, of compensating for the loss of light it might otherwise occasion.

These reasons in favor of an incomplete removal of the carbonic acid are moreover strengthened by the fact, that in separating the last portions of this impurity by the dry lime, or other purifying process, we at the same time arrest a small portion of the illuminating ingredients of the gas, and thus run the risk of weakening, instead of strengthening its illuminating power.

These vague and uncertain impressions as to the action of small quantities of carbonic acid, and as to the economy of its removal, suggest the importance of a thorough experimental investigation on the subject, and have led me to make the series of observations which follow; offering, I believe, the first conclusive results thus far published on this interesting question in the science and economy of gas lighting.

Mode of conducting the experiments.—1. The carbonic acid was evolved from Bi. Carb. Ammonia, by the action of dilute sulphuric acid, using the common form of self-regulating apparatus, and passing the gas through water in a wash bottle properly connected with the exit pipe.

2. The mixture of carbonic acid and gas was made in a diaphragm gas-holder, from which it was afterward delivered to the burner in the photometric experiments. To effect this mixture, gas was turned on to one side of the diaphragm, and the other compartment, as far as possible, emptied. The carbonic acid was then turned in upon the latter until a sufficient volume was introduced, then this compartment was filled with gas, the first gas admitted being expelled in corresponding quantity from the other side. The whole being closed in, the vessel was repeatedly inverted and turned from side to side, with the view of thoroughly incorporating the contents, and when this was thought to be effected, and before connecting the holder with the photometrical apparatus, a portion of the mixture was taken out for analysis.

3. The percentage of carbonic acid in the mixture was determined in a graduated tube over mercury. In the first experiment the tube was filled by displacement through mercury. Afterwards it was found more convenient, and quite as accurate, to fill by displacement with a long inserted tube in air.

The absorbent was a ball or rod of caustic potassa (the latter being the more prompt), fixed upon the end of a long wire.

4. The illuminating power was determined by passing successively the common gas and the mixture through the same dry meter, at equal or nearly equal rates (5 feet per hour), and burning them from the same 15-hole argand burner, and comparing their respective lights with a third light, also burning 5 feet per hour, at the other end of a photometric bar, 150 in. long.

These two results were then reduced to equality of delivery.

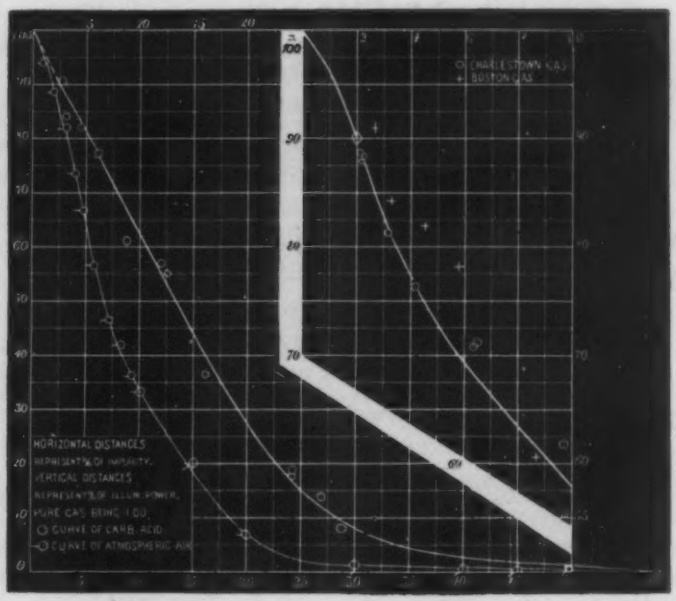
EXPERIMENTS.

		CO_2	Ill. Power.
(1.)	Boston Gas, containing about	2·6 p. c.	1·000
	Mixture " by determination	24·	·203
	" " "	26·6	·152
	" " "	16·25	·400
	" " "	8·75	·667
(2.)	Boston Gas, " "	2·5	1·000
	Mixture " "	12·5	·609
	" " "	29·	·084
	" " "	58·5	·000
(3.)	Boston Gas, " "	2·50	1·000
	Mixture " "	24·	·193
	" " "	12·	·619
(4.)	Boston Gas, " "	2·8	1·000
	Mixture " "	4·6	·903
	" " "	4·4	·936
(5.)	Boston Gas, " "	2·4	1·000
	Mixture " "	3·3?	·921
	" " "	5·8	·854

NOTE.—From the above we obtain the following table: Allowing 2·6 per cent. = to produce a loss of 2·6 × ·0364 = 094 loss of light.

Per cent. CO_2. Pure Gas 0.	Ill. Power = 1000.	Loss.	Per cent. loss Ill. Pow. for each per cent. CO_2.
2·6 =	·906	·094	...
3·3 ? (4·3)	·840	·160	5
5·8	·779	·221	4
4·5	·820	·180	2
8·75	·604	·396	4½
12·	·563	·437	3½
12·5	·554	·446	3½
16·25	·363	·637	3¾
24·	·183	·817	3½
24·	·175	·825	3½
26·61	·137	·863	3⅛
29·	·076	·924	3⅛
58·5	·000	1·000	...

I have put these results in the form of a curve, and, for the purpose of comparison, have added a curve representing the loss due



to the addition of atmospheric air, taken from Audoin and Bérard's Experiments. *Annales de Chemie*, &c., 1862.—F. E. S.

In the next experiments the gas was passed through hydrated lime, according to the ordinary method of the dry lime process.

(6.)	Boston Gas, Carbonic Acid (undetermined)	1·000
	The same purified through Lime, "	1·060
(7.)	Boston Gas, Carbonic Acid, 2·2 per cent	1·000
	The same partially Purified,	1·030

The difference between experiment 6 and 7 may have been partly due to the presence of a larger amount of carbonic acid in the former case. This small effect on the illuminating power of the 2 per cent. of carbonic acid taken out is in striking contrast with that observed in the former case, where 2 per cent. was added, and leads to the suspicion that the lime removes some of the illuminating ingredients at the same time that it abstracts carbonic acid.*

(8.) The lime was removed and replaced by broken fragments of pumice-stone, boiled down in solution of potassa (13°) until the water was nearly all evaporated.

Partially purified gas, carbonic acid	0·3	per cent.	1·070
Boston Gas, " "	2·7	"	1·000
" " purified " "	0·	"	1·055
(9.) " " " "	2·7		1·000
" " purified " "	0·5		1·073
(10.) Boston Gas	2·58		1·000
Purified so that it did not act on baryta water while passing through for 5 minutes	0·		1·061
The same partially purified	1·61		1·035

These results not being altogether satisfactory, further experiments were made upon gas manufactured by the Charlestown Gas Light Company, in the office adjoining their works.

This gas was purified by the dry lime process, and being nearly free from carbonic acid, was well suited for determining the effect of small additions of this impurity on the illuminating power. Observations with the absorption-tube, made at intervals during

* Indeed, both in these and next two experiments with potassa, the purifying material was colored slightly green by the absorption of some other ingredient than carbonic acid.

It was found, also, that the lime and potassa soon ceased to act upon the acid, and, on opening the purifier, this loss of action was accounted for by finding the purifying material quite *dry*. It action could be restored again, for a time, by remoistening it. That this inaction does not occur so soon when the crude and sulphurous gas is acted upon in the ordinary dry lime process, I think, is quite clear, for I have frequently determined the carbonic acid in gas purified by that process, and have found, almost without exception, that when the sulphuretted hydrogen was taken out, I could discover but faint traces of carbonic acid. And it has been equally true, that when sulphuretted hydrogen was present, carbonic acid was also present.—F. E. S.

the continuance of the experiments, gave the percentage of carbonic acid in the gas 0·3, 0·3, 0·2, 0·2.

The following table gives the results obtained by these experiments: pure gas being 1·000.

Per cent. Carb. Acid in gas.	Ill. Power.	Loss of Ill. Power.	Loss per cent. Ill. for per cent. CO_2.
1·0	1·000		
1·9	·900	.100	5·2
2·1	·888	·116	5·5
2·2	·878	·122	5·5
3·1	·814	·186	6·
4·2	·769	·231	5·5
6·6	·707	·293	4·4
6·7	·710	·290	4·3
9·7	·555	·444	4·5
9 7	·618	·318	3·9

From these results, it would seem that at least 10 per cent. of the light was destroyed by the addition of 2 per cent. of carbonic acid; and it is but reasonable to expect that if we could take out that 2 per cent. without removing any illuminating ingredient, there would be a corresponding gain.

LIST OF OBSERVATIONS ON THE POLARIZATION OF THE CORONA.

By Prof. Edward C. Pickering.

In the observations of the eclipse, on the 22d December of last year, one of the principal questions to be determined will be the constitution of the corona. As both the spectroscope and polariscope will be used for this purpose, and it seems desirable to collect what has already been done with these instruments. The observations with the spectroscope are well known, being confined to the eclipses of 1868 and 1869. In the former, nothing unusual was seen in the corona spectrum, and it was supposed to be the same as that of the sun. The observations of last year, however, especially those of Prof. Young, showed no dark lines, but at least one bright one. The observations with the polariscope are more scattered, but the following list includes the most important. I have endeavored to give, where possible, the exact words (or the most literal translation) of each observer's report, with the place of its publication, and in some cases a short criticism.

This question appears to have been first suggested by Arago in

1842. He says: "It is not probable that the light of the luminous lunar corona can show traces of polarization. It would still be well to determine the fact by the aid of a polariscope."—*Comptes Rendus, XIV*, 1842, *p.* 855.

ECLIPSE OF 1842.

Arago at Perpignan.—"I instantly seized a polariscope *à lunules*, that was beside me; I handed over to M. Victor Mauvais a colored banded polariscope, and began to explore with my instrument the environs of the luminous aureole, the aureole itself, and even the atmospheric region which was projected on the lunar disk. Everywhere I saw the two *lunules* tinted with the complementary colors which indicate, infallibly, the presence of polarized light in every ray subjected to the delicate analysis of the instrument." As he was unable to determine the intensity of the polarization, or to tell whether that of the corona was more marked than that of the adjacent sky, he concludes: "I have no means of judging, from my observations, whether the light of the corona is polarized or not."—*Arago's Astron. Populair, III*, 642.

Mauvais at Perpignan.—"During the total eclipse I directed a polariscope called Savart's to the moon and the ring, and I saw iridescent bands. The maximum of intensity corresponded with the horizontal position of the bands. They were very bright on the ring, and beyond; they appeared less distinct on the moon itself, yet were distinctly visible even there."—*Arago's Astron.*, III, 642.

The brightness of the lines must have been at a maximum when vertical as well as when horizontal, since the intensity in positions at right angles is always equal. Apparently each image observed by Arago was of uniform color throughout, and therefore its plane of polarization everywhere the same, and the observation of Mauvais shows that this plane was not inclined, but either horizontal or vertical.

ECLIPSE OF 1851.

Abbadie at Fredericksworrk.—"I had inserted a plate of quartz between the object-glass and eyepiece of my telescope, and applying a double refracting prism to the eyepiece as an analyzer, I perceived that the light of the ring was strongly polarized. I could not distinguish any trace of color on the dark disk of the moon, but the clouds may have been less transparent in that part."—*Arago's Astron.*, III, 610.

Dunkin at Christiania.—"Troubled by clouds. Little appearance of the corona was seen, and not a trace of polarization; green was as bright as any other color."—*Astron. Month. Notices, XII*, 45.

The last statement, which seems to have puzzled the writers of the time, was probably made to refute an earlier observation, to the effect that green was absent in the light of the corona, and has no relation to the test for polarization. See accompanying letter.

Carrington at Lilla-Ider used a Nicols prism. "I tried this means for an instant on the ring, but without success." His instrument was in good order, since, when directed to the atmosphere at a suitable distance from the sun, it indicated the existence of polarized rays.—*Arago's Astron., III*, 610.

Eclipse of 1858.

Liais at Paranagua.—Instruments used, a tourmaline plate and Savart's polariscope, "which, many have assured me, renders most distinct the existence of polarized rays, and the direction of their plane, which is normal to the limb. The double refracting prism of small angle has enabled me to recognize that the protuberances gave two equal images in spite of the polarization of the base on which they were projected, because the slight separation of the two images rendered this polarization equal for both." The neutral point in the atmosphere, he states, was in the region of the sun; hence, no confusion was possible. "Moreover, if I have found the polarization of the corona feeble, compared with the ordinary atmospheric polarization, I no less declare that it is undoubtedly much greater than other polarizations well known, such as that of the surface of the moon. It was even perceptible by a small Savart's polariscope, which did not allow us to see the bands on the moon in the conditions of the maximum polarization of this body."—*Comptes Rendus, LI, p.* 769.

As the atmospheric polarization is caused by the sun, the neutral points are always at a constant distance from this body, and it is difficult to understand how the sun could then coincide with them, rather than at any other time.

Eclipse of 1860.

Abbadie at Briviesca.—Used double image prism and plate of quartz, giving contiguous imagas. He found the light of the protuberances unpolarized.—*Comptes Rendus, LI, p.* 705.

Secchi on the summit of Mt. Michel.—"I then placed my eye to an Arago's polariscope, already directed very near the sun, and I perceived that the two images were not of equal color, and that the corona in one was elongated in one direction, and in the other in a direction perpendicular to the first; but I could only give a few seconds to this examination."—*Comptes Rendus, LI, p.* 158.

It seems as if the elongation observed must have been imaginary, since the plate of quartz or selinite in the polariscope would have prevented this effect, while if they had been removed by accident, no difference of color would have been perceptible. We could only account for either effect separately, but not for their simultaneous appearance.

Prazmowski at Briviesca.—Used a telescope, with terrestrial eye-piece, magnifying 22 diameters. At common focus of object-glass and eye-piece, a quartz plate of double rotation was placed, its thickness being such as to give the sensitive tint. A Nicols prism was interposed between the first and second lens, where the bundle of rays was most narrowed. The distinctness of the image was not thus affected. The field was divided into two parts by a black line, and the prism and plate turning together, there was absence of color only when this line coincided with the plane of polarization. The image of the sun was brought into the centre of the field, the line of junction being vertical, and cutting the disk into two equal parts. Two segments of the corona were seen not equally colored throughout. The upper and lower extremities of each segment in contact with the line of junction of the quartz were always uniformly colored; to the right and left of these extremities the two halves were strongly colored of complementary tints, one red, the other green.

A motion of rotation imparted to the eyepiece around its axis did not change the colors with regard to the line of separation of the quartz. The light of the corona was then polarized, and its plane of polarization coincided with the normal to the contour of the moon.

This was not a mere trace of polarization, but most intense colors; on one side a most brilliant ruby (*le rubis le plus vif*), and on the other, the perfect emerald green (*l'emerande la plus pure*). As well as I remember, the part of the corona most strongly colored did not correspond with the most luminous portion, but is found at a certain distance from the circumference of the moon.

A second telescope, of twice the power of the first, was used for the protuberances. Between the first and second lens of the eyepiece was placed a plate of quartz, perpendicular to the axis (*perpendiculair à simple rotation*), giving a red tint. In front of the eyepiece, a double refracting prism of small angle was placed, separating the images $1\frac{1}{2}'$. The protuberances were thus separated, but the corona images overlapped, giving a white background. By this means it was found that the light of the protuberances was unpolarized.—*Comptes Rendus, LI, p.* 195.

These observations seem to have been made with great care, and are among the first that are recorded with sufficient detail to permit of a careful criticism. Unfortuately, two errors occur in the fundamental statement that the two halves of the field are colorless when the line of junction is parallel to the plane of polarization. In reality they are never colorless, but in this position are of the same color, and, what is more important, they are again, of a uniform tint when the line of junction is perpendicular to the plane of polarization. This is obvious from the theory, and is verified by experiment. Let us now see what would have been the appearance, if the corona had been strongly polarized in planes passing through the sun's centre. The upper and lower, or N. and S. parts, would have been of uniform color on each side of the line of junction, since their plane of polarization would have been parallel to it. The E. and W. parts would also have been alike, since their plane is perpendicular to the line of junction. The most marked colors, however, would have been at angles of 45°, the N. E. and S. W. being alike, and complementary to the N. W. and S. E., one being red, the other green. These appearances would be so striking, and so utterly unlike those actually observed, that there seems no chance of their being mistaken.

Eclipse of 1868.

Campbell at Jamkandi.—Used a 3-inch telescope, with three eyepieces, giving powers of 27, 41 and 98, two analyzers, a double image prism and a Savart's polariscope. First, with a power of 27 and a field 45′ diameter. "A most decided difference was at once apparent between the two images of the corona." He then applied the Savart's polariscope, which gave bands at right angles to the limb, distinct but not bright, and with little if any appearance of color. On turning the polariscope in its cell, the bands, instead of appearing to revolve on their own centre, passing through the va-

rious phases of brightness, arrangement, &c., travelled bodily along the limb, always at right angles thereto, and without much change in intensity or any at all in arrangement.

The point at which they seemed strongest was about 140° from the vertex, and I recorded them as "black-centred." Changed to eye piece, giving power of 41, and the first clear instant showed the bands much brighter than before, colored, and as tangents to the limb, at a point about 280° from the vertex.—*Proc. Roy. Soc.*, 1868, *November* 19, *p.* 122.

Winter at Masulipetan.—He used a telescope of Cooke and Sons, of 2½″ aperture and 28″ focal length, with a Savart's polariscope, and double image prism and quartz plate cut perpendicular to the axis. On examining the light from the corona, by means of the Savart's polariscope, he fouud it very strongly polarized every where in planes radial to the sun's centre. The bands were extremely vivid near moon's limb, and faded off with the corona. Several portions of the corona were successively tried, and in all the white central bands were brightest where they were radial to the sun, and the black central bands were equally marked when they were tangential to the limb.—*Phil. Mag.*, *Jan.*, 1870, *p.* 17.

Eclipse of 1869.

Smith at Eden Ridge.—In a note to the writer, Prof. Smith, states that a member of his party found, that with "an Arago polariscope, decidedly *no traces of polarized light could be detected* in the light of the corona."—*Dec.* 20*th*, 1869.

Pickering at Mt. Pleasant,—The writer used an Arago's polariscope, and observed that "the two images were precisely alike and both pure white, but one was on a blue, and the other on a yellow background. From this we infer that the corona was unpolarized or at least that the polarization was too slight to be perceptible." The colored background was accounted for by light reflected by the sky from the earth beyond the limits of the shadow."—*Jour. Frank. Inst.*, *Oct.*, 1869, *p.* 285; *Dec.*, 1869, *p.* 372.

It is difficult to account for the great variation in these results. Moigno suggests that it may be due to real variations in the corona, but this seems scarcely probable. The polarization of the sky may have some influence, and if this is due to the light reflected from the earth beyond the limits of the shadow, would depend on the sun's altitude, and whether the illuminated surface were land

or water The polarization may be very slight, and hence not perceptible with some of the instruments. A series of experiments are now being conducted in the Physical Laboratory of this Institute by Mr. W. O. Ross, to compare the delicacy of different polariscopes, and to show how small a proportion of polarized light each will show. It seems scarcely possible, however, that the marked polarization described by Prazmowski and Winter could have escaped any observer. If the corona is polarized radially, each image in an Arago's polariscope should be of uniform tint throughout any diameter but of complementary colors in diameters at right angles. Thus, if in one the N. and S. parts were red, the E. and W. parts would be green, while these colors would be reversed in the other image. So marked an effect could scarcely have been passed unnoticed by the four observers who used this instrument, had the polarization been intense. We must therefore regard it as beyond the power of this instrument, although it might still be detected by a Savart's polariscope, which is much more delicate. Arago and Mauvais appear to be the only ones who detected polarization within the moon's disk, while Prazmowski and Winter obtained precisely opposite results as regards the comparative intensity of the polarization in the bright and faint parts of the corona. Our knowledge then of this subject is still, therefore, very limited, and further observations are much to be desired.

Mass. Institute of Technology, Oct. 29th, 1870.

ON A BLOW-PIPE ASSAY WITH THE AUTOMATIC AIR-BLAST.

By Le Roy C. Cooley, Ph.D.

The blow-pipe furnishes an easy means of detecting the presence of precious metals; but, for reasons shortly to appear, its use has been, for the most part, limited to this purpose, and the furnace has been resorted to whenever a determination of the value of the ore has been desired. The simplicity and elegance of the blow-pipe assay have, however, prompted many attempts to make this instrument take the place of the furnace. Systems of quantitative analysis, with it, have been devised by Plattner and others, which, in the hands of skilful operators, do, doubtless, give satisfactory results, but they have never become popular with assayers. The objections to these methods do not spring from any want of confi-

dence in the chemical actions involved—these are satisfactory—nor do they arise from the amount of labor required, for this is less than that of the furnace assay. The objection to the use of the blow-pipe in determining the value of ores springs from the necessity of using such small quantities of ore that the silver button obtained is too minute to be satisfactorily valued. Rarely will this button be large enough to be weighed; its value is sought by measuring its diameter and comparing it, with that of another button whose value is known, on the principle that spheres are to each other as the cubes of their diameters. Delicate and ingenious scales have been devised for this purpose. But even if we allow that these minute diameters are, in any case, measured with sufficient accuracy, yet there still remains the fact that the little buttons can never be exact spheres, and it may well be doubted whether they ought to be considered as being truly similar solids.

If, then, the blow-pipe is ever to rival the furnace in assaying the ores of the precious metals, the first thing to be secured is the ability to operate with it upon larger quantities of material. For this purpose a larger flame must be obtained, and this necessity requires that the lips of the assayer be relieved from the fatigue of furnishing the air-blast. An automatic source of air is indispensable. If, however, the proper proportions of air and gas be furnished, it is no more difficult to produce a very large flame with oxidizing and reducing power, at will, than it is to obtain the ordinary blow-pipe flame possessing these powers. Such a flame once obtained, will evidently be able to bring about the proper chemical reactions in a large mass, with as much elegance and accuracy as the mouth blow-pipe flame does in the small quantity usually employed, and with much less labor on the part of the assayer.

The apparatus lately described in this *Journal* (October, 1870)—the *automatic air-blast* for laboratory purposes—furnishes exactly the kind of air-current necessary to produce the desired flame. With a Bunsen blow-pipe, provided, as it is, with an air jet in addition to the ordinary gas jet and collar of the common Bunsen burner, and with this automatic blast, gentle or strong at will, but always steady, the assayer has such complete control over the proportions of air and gas in his flame that he is able to regulate its heating, oxidizing and reducing power at his pleasure. With a flame so reliable in these respects, and at the same time so large as this one may be made, the assayer is able to scorify and

cupel a quantity of ore quite as large as would be taken for the furnace assay. The ordinary scorifying dishes and cupels of the furnace assay are used, and the same proportions of assay lead and fluxes may be employed.

The heat of the flame is sufficiently intense to keep the scorifyer and cupel in a glow without assistance from other sources, but if these vessels are placed over the flame of a laboratory lamp, its heat will facilitate the operation by allowing the energies of the blow-pipe to be directed more exclusively to the chemical actions which it is required to produce. Moreover, if the supply of water and gas is abundant, a blow-pipe with two or three jets can, doubtless, be made and fed, whereby as many assays may be simultaneously conducted.

That the accuracy of this blow-pipe assay is quite equal to that of the furnace assay, has been found by repeated comparison of results obtained from the same ore by the two methods, Indeed, the accuracy, neatness and simplicity of the method, together with the cheapness of the apparatus required, seem to justify this public description, and the hope that it will not be entirely unwelcome.

THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.)

By B. A. Gould.

(Continued from Vol. LX., page 423.)

Now, as for the spots. It is said that seven cities contended for the honor of having given birth to Homer. Almost, if not quite, as many claim the invention of the telescope,—yet there is small room for doubt that the first published account of such an instrument was in Holland, in October, 1608, and that the knowledge of its existence found its way only gradually through Europe, rumors of its existence meanwhile stimulating to independent inventions of the same wonderful contrivance.

No sooner had this new implement of research been turned upon the sun than it of course revealed the spots conspicuously to the observer. It is related that at a yet earlier date, the existence of solar spots had been known to the Chinese and to the Peruvians, and that one of the ancient Incas had not scrupled to express his

doubts as to the divinity of the sun, after seeing a large spot upon his face. But our first authentic accounts of them come from John Fabricius, a native of Friesland, who had a Dutch telescope at Wittenberg, with which he discovered a solar spot as early as February, 1611. In June of that year he published a little treatise* about them, and showed that they moved round the sun. Not more than a couple of months later, Scheiner, at Ingolstadt, of whom I have already spoken, and who was the first to avail himself of colored shade-glasses, also saw them;† and about the same time, probably, or a little later still, Galileo at Florence found them likewise.‡ A sharp discussion arose between Galileo and Scheiner, as to the priority of discovery; but it seems pretty clear‖ that each, without knowledge of their detection, either by the other, or by Fabricius, had discovered the spots as early as April or May, 1611. The announcement that even the sun, the fountain of light, was not without its blemishes, was received with general incredulity.§ Scheiner did not venture to publish his results otherwise than anonymously —"not wishing," as he afterwards said, "to connect his name with a matter so unexpected, and to many so suspicious." Even eight years after the publications of Scheiner and Galileo, a French priest, Jean Tarde, undertook to prove¶ that the spots were simply planets, revolving around the sun, and, in that spirit of adulation which is not yet extinct, he baptised them the "Bourbon Stars." They could not be spots, he said, for the sun—the eye of the world—could not have the ophthalmia!"

To explain the phenomena of the spots, Domenic Cassini, the same astronomer whose determination of the sun's parallax was mentioned in the last lecture, suggested** in 1671 that the sun's surface must be an ocean of light, surrounding the dark solid central body of the sun, and whose tumultuous agitation sometimes discloses some mountain summit, which appears as the black nucleus of the spot. This suggestive idea formed, however, only

* *Narratio de Maculis in Sole observatis.* Wittenberg, 1611, June 4. 5 pp. qto.

† *Apelles latens post tabulam.* (Three letters to Mark Welser.) 1612, Aug. 5.

‡ *Discorso intorno alle Cose que stanno in Acqua.* Florence, 1612.

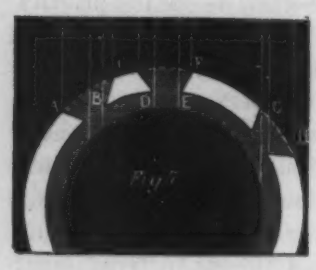
‖ See Arago. *Annaire pour l'an*, 1842, p. 465.

§ Winnecke, "*Ueber die Sonne*," p. 11, states that there is evidence that both the Chinese and the Peruvians have recorded, at an earlier date, the existence of spots visible to the naked eye.

¶ *Borbonia Sidera*, etc. Weidler. *Hist. Astron.* p. 623. *Kosmos*, III, 408.

** Delambre. *Hist. de l'Astron. Moderne*, I, 387.

a first step toward the solution of the problem—the honor of which belongs to a Scotch astronomer, Prof. Alexander Wilson, of Glasgow, one hundred years later. Wilson observed* that the penumbra, or grayish border, which surrounds the dark nucleus, and which is generally of about equal width on all sides when the spot is near the middle of the sun's disk, always became narrower on the side nearest to the middle of the sun, when the spot approached the circumference. Hence, he inferred, in 1773, that the spots were funnel-shaped apertures in the luminous envelope, which disclosed the dark body of the sun at the bottom, and whose shelving sides constituted the penumbra. A moment's inspection of the diagram will show how such an aperture would, at the middle of the disk, exhibit the full size of the nucleus, D. E., and an equable border, represented by the apparent breadth at C. D. and E. F. of the inclined sides of the opening; but that when it is nearer the circumference, as at A. B. or G. H., the nearest side becomes foreshortened, as does also the nucleus, though to a less extent, while the farthest side of the aperture is presented much more fully to the view.



If, therefore, the appearances be as stated by Wilson, the inference seems irresistible that the spots are openings in the glowing envelope of the sun. This view was long accepted without doubt, but it has in recent years been called in question; and to make sure of the facts in the case, the Directors of the Kew Observatory have carried out an extensive examination of all the drawings and photographs of solar spots which they could make available. They had a valuable series of drawings and measurements made by Carrington in England, and extending over nearly seven and a half years, all on a scale of one foot to the sun's diameter; they had the magnificent collection of drawings made during forty years by Schwabe, in Germany; and furthermore, a series of photographs taken under M. De La Rue's superintendence, during nearly four years. Applying to these materials the statistical method, which is eminently adapted for an investigation where so large numbers are available, and measuring the relative dimensions of the penumbra on each side, they obtained the following results:—Considering

**Phil. Trans.* 1774. LXIV, Pt. 1, p. 6.

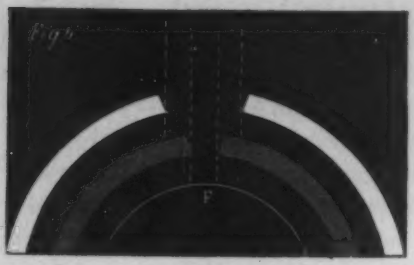
the spots only with reference to their positions, right and left of the central meridian line of the sun, they found, out of 605 cases, only 74 in which the penumbra was widest on the outer side; while out of 89 spots measured with reference to their position north or south of the sun's equator, there were but 17 which failed to exhibit the same conformity with Wilson's theory. This enormous preponderance of observations in its favor must be regarded as doing much toward settling the question; and we must infer that of those few cases which do not appear to support this theory, the explanation is to be found in an actual inequality in the width of the penumbra on the two sides, too great for the marginal foreshortenings to counterbalance. Mr. De La Rue has also suggested the use of the stereoscope for deciding whether the spots are actually cavities or depressions. Photographs of the spots, taken at different moments, with an interval sufficient to present them in an appreciably different position, give, when viewed in the stereoscope, an unmistakable appearance of indentations. But this argument, although a strong one, can hardly be deemed conclusive, inasmuch as our senses are often trickey guides, and things are not always what they seem. A stronger evidence of the sort is afforded by a photograph of the Kew series, which exhibits a notch in the circumference of the sun corresponding to the point of disappearance of a spot.*

But why should the sloping side of such a cavity manifest that diminution of the solar lustre which the penumbra exhibits? Because the darker body of the sun would be partially seen through, would be our first reply; but a moment's thought will show that were this the true explanation, the penumbra would exhibit different degrees of luminosity, and shade gradually away from full brightness at its circumference to darkness at its inner margin. This is not the appearance, but, on the contrary, the boundaries of the penumbra are sharply and distinctly defined, and its color is tolerably uniform throughout. To meet this difficulty, the German astronomer, Bode,† assumed a second envelope, of a cloudy nature, snpported by an atmosphere, and situated between the true body of the sun and the photosphere, as the outer light-giving envelope is called. The reflection of the photosphere from the surface would account for all the light of the penumbra, while the nucleus of the

* *Comptes Rendus*, LXVII, 1009.

† *Beschäft. d. Berliner Gesellsch*, etc., II, 237; *Kosmos* III, 410.

spot would be the body of the sun, as seen through the opening in this second envelope. The structure would then be as represented in this diagram, where A. B. represents the bright outer envelope, and C. D. the intermediate one, shining only by reflected, light and screening the dark body of the sun, E. G., excepting at the point F.



Twenty years later, when the great William Herschel came to study these phenomena, he arrived at results* essentially the same as those of Bode; but he added the idea that the transparent elastic atmosphere, in which the stratum of clouds must be suspended at a height of some thousands of miles, likewise supported and extended beyond the photosphere. And to the action of this elastic fluid of unknown nature he attributed various phenomena observable at this outer surface. Emanating from the true surface of the sun, this gaseous atmosphere streamed upward, displacing the material of the surrounding cloudy stratum and of the thinner photosphere. It is a curious fact that a hypothesis almost identical with this theory of Herschel had been propounded as early as the middle of the fifteenth century, before the existence of the spots was known to astronomers; yet this must be regarded rather as a fortunate guess than as a scientific theory, for the evidence by which alone this view can be supported was not then known.

The general aspect of solar spots will be seen from the representations in Plate II.† The irregularity of their outlines almost defies

* *Philos. Trans.* 1795; 1801, pt. 2, pp. 270, 318.

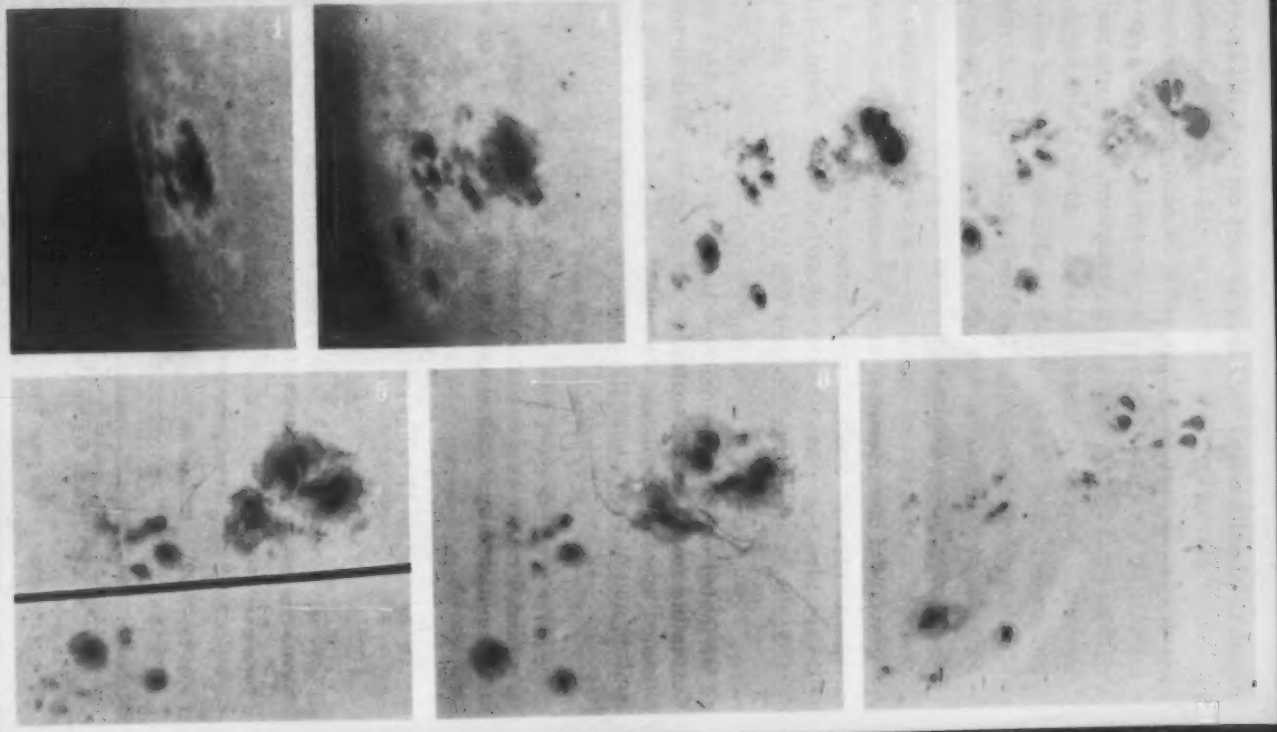
† This Plate is an actual photographic reproduction from a series of negatives, made by Mr. L. M. Rutherfurd, of New York, showing the changes undergone by a remarkable spot on seven consecutive days

The exact dates of the series of pictures given in Plate II, are as follows:

							Sidereal Time.
1	September	19th,	1870	9h	·06m	·15s.	
2	"	20	"	9	·00	·00	
3	"	21	"	15	·00	·00	
4	"	22	"	9	·52	·10	
5	"	23	"	9	·27	·50	
6	"	24	"	11	·44	·55	
7	"	26	"	8	·26	·30	

Between 6 and 7 the interval is of two days, the intervening one having been cloudy. The black line on 5 gives the true east and west direction, which is the same in all.

The preparation of this plate was as follows:—Enlarged positives on glass were made from the 7 original negatives, and the required portions were cut out with a diamond in rectangular plates. These were then set together in order, and negatives were made from them, which, with strips of paper to cover the irregular marks produced at the lines of junction in the composite positive, were used in printing the necessary edition of this plate.—EDS.



Phot. by L.M. Rutherfurd. Printed by J. Cremer.

description, and it must be remembered that this outline is undergoing continual change.

The enormous magnitude of some spots has been already mentioned—huge chasms, which cover an area of some two billions of square miles, and whose mouths would receive at once forty or fifty globes as large as our earth. Their continual and rapid changes of form and size make it peculiarly difficult to settle many interesting questions concerning them, but decided indications of rotary motion have been observed in many of them, which would imply that, to some extent at least, they were turning like huge whirlpools around their own centres. The nucleus—although we speak of it as black, and although it appears intensely so in contrast with the glowing radiance of the surrounding portions—is in itself by no means devoid of brightness. Herschel endeavored to estimate the comparative light from the penumbra and nucleus, and came to the conclusion that the penumbra possessed in general about 47 per cent., and the nuclues about $\frac{7}{10}$ths of 1 per cent. of the luminous power of the solar surface. More recently, Chacornac has arrived at not dissimilar results, and it has been well said by Winnecke* that, were the light of the whole sun to be extinguished, excepting that portion radiating from the nucleus of a spot, our eyes would scarcely be able to endure the dazzling beams. Herschel's estimate has generally been regarded as too low, yet it would give to the dark nucleus of a spot a luminous intensity nearly 2500 times greater than that of the full moon. When Schwabe observed the transit of Mercury, in 1832, he was astonished† at the blackness of the planet as seen against the nucleus of a spot as a background. But a late English observer, Mr. Dawes, has pointed‡ out that even in the nucleus there are often places blacker than the rest, and for these he would reserve the name *nucleus;* calling the other portion only by the name umbra, or shadow. Perhaps it may be needless to mention that, to account for this appearance, still another solar envelope was summoned into existence, in the same way that one had been improvised for each of the preceding grades of brightness observed; and in the new theory what is seen as the umbra becomes a third envelope, while the darker points observed in it are to be regarded as the true body of the sun.

(To be continued.)

* *Ueber die Sonne*, p. 31.

† See, also, *Astron. Nachr.*, LXIV, 130.

‡ *Monthly Notices, R. Astr. Soc.*, XXIV, 36, 57.